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NATIONAL GEOGRAPHIC

A Thirsty Planet

Produced by National Geographic Maps for National Geographic Magazine

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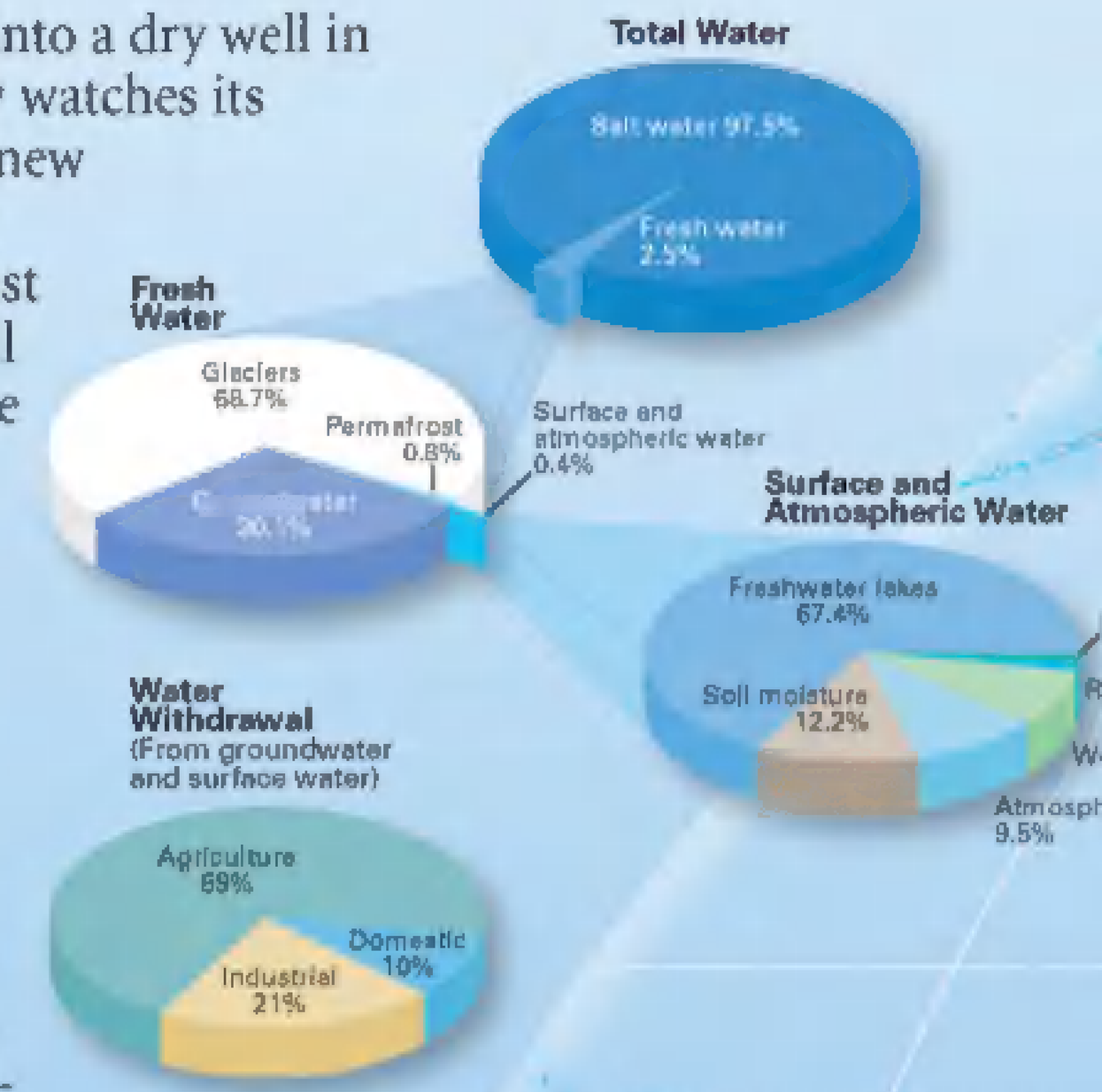
Washington, D.C., September 2002

Women wait to haul water from an irrigation canal in southern Ethiopia, an area plagued by drought. More than 80 percent of rural Ethiopians lack access to clean drinking water.

PETER ESSICK

A woman drops a bucket into a dry well in Africa. A Chinese family watches its home vanish beneath a new reservoir. An Australian farmer kicks the salt crust slowly poisoning his field. In all corners of the globe people face trouble with water. It is the tie that binds every living thing, as vital to life as air. Yet one-third of the world's people live in countries where water supplies often don't meet demand; more than a billion lack access to clean drinking water altogether. Those numbers will drastically increase in the next 25 years as the population grows. It's not that we're running out—Earth is awash in water, continuously recycling the same amount it's had for eons. But accessible fresh water in lakes, rivers, and aquifers, often called renewable water, is less than one-tenth of one percent of all Earth's water—and it rarely lies where it's needed most. We've tapped half of it already, and many of the world's great watersheds now suffer from pollution, overexploitation, and political conflict. Have you checked your water source lately?

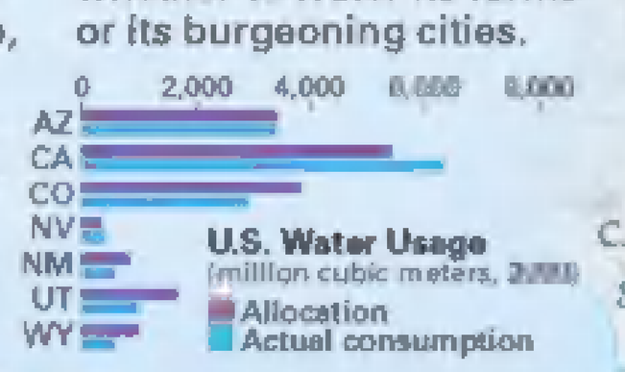


The Colorado River, carver of the Grand Canyon, is barely a brook by the time it reaches Morelos Dam at the U.S.-Mexico border.

COLORADO RIVER BASIN—Demand Exceeds Supply

COLORADO WATERSHED AREA 271,480 sq mi (703,132 sq km); URBAN GROWTH RATE 2.1%; POPULATION DENSITY 26 per sq mi (10 per sq km); LARGE CITIES 7

Early explorers dismissed the Colorado as one of those rivers that was "too thick to drink, too thin to plow." Today it's the lifeblood of the booming, if parched, American Southwest. Seven states and Mexico use nearly every drop, reducing a once lush delta on the Gulf of California to a sliver in a sunbaked mudflat. The river slakes the thirst of more than 25 million people and irrigates some of the nation's most profitable farms in California's Imperial Valley. But California has long taken more than its share. As demand in other states grows, it will soon have to decide whether to water its farms or its burgeoning cities.

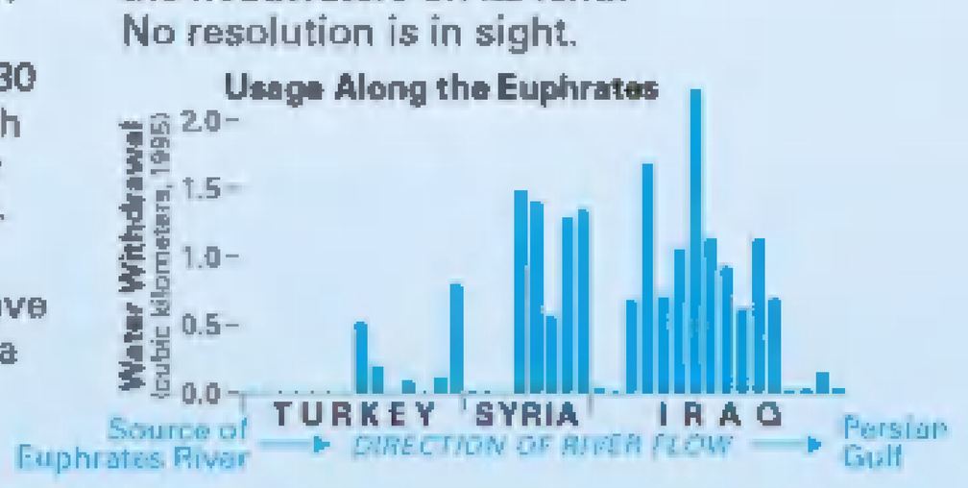


Water pipes funnel the Euphrates River to turbines in Turkey's Atatürk Dam, the linchpin of a controversial plan to irrigate southeastern Turkey.

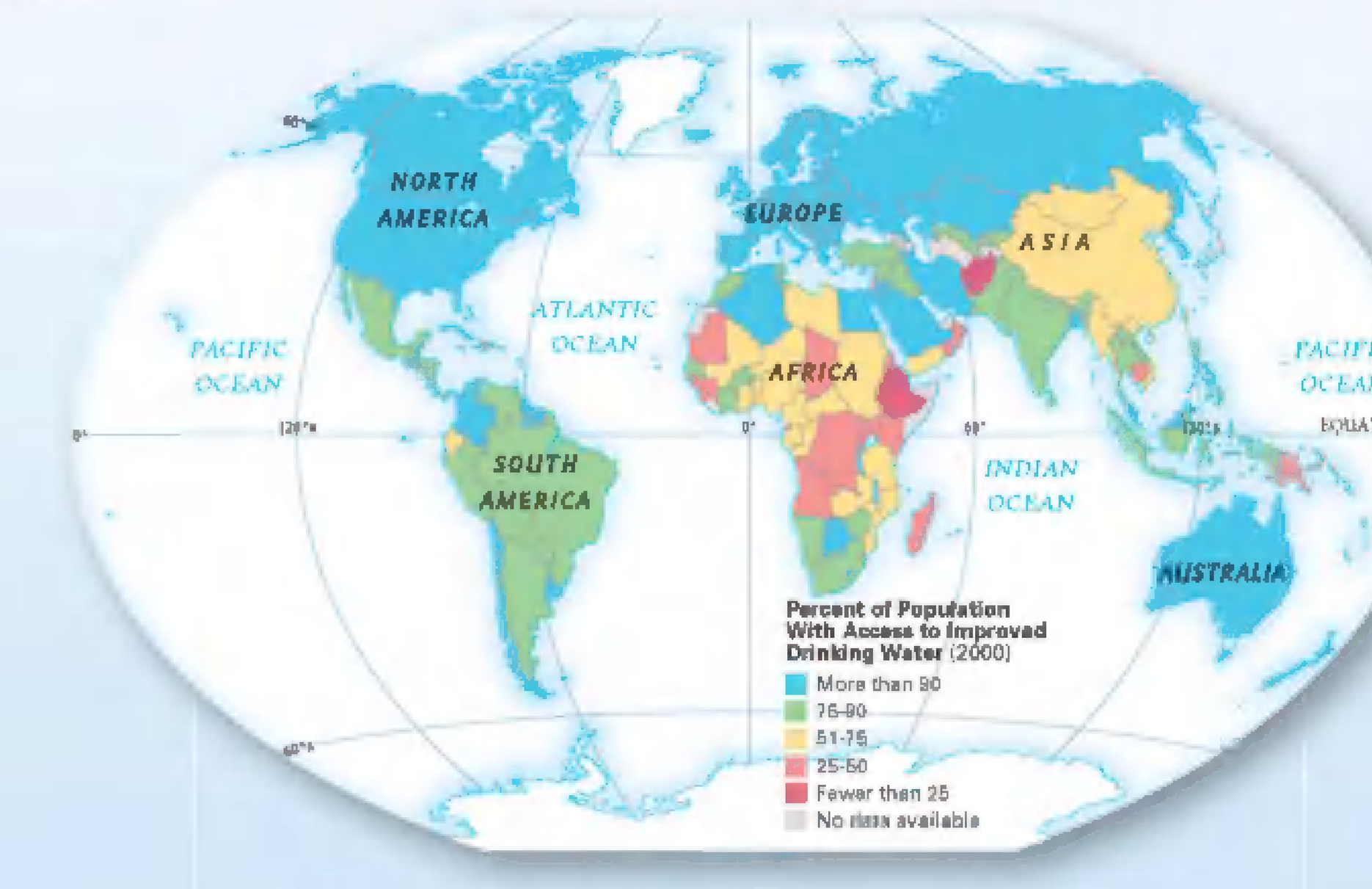
TIGRIS & EUPHRATES WATERSHED—Whose Water Is It?

TIGRIS & EUPHRATES WATERSHED AREA 295,689 sq mi (765,831 sq km); URBAN GROWTH RATE 3.9%; POP. DENSITY 148 per sq mi (57 per sq km); LARGE CITIES 27

A modern water war is brewing in the cradle of civilization. The Mesopotamians first used water from the Tigris and Euphrates Rivers more than 7,000 years ago. Today Turkey, Syria, and Iraq have built more than 30 dams on the rivers, enough to capture their flow many times over. Iraq has threatened to bomb upstream dams. Syria and Turkey have come close to blows over a Turkish irrigation project. Syria and Iraq claim water-use rights dating from prehistory, and Turkey demands sovereignty over the headwaters on its land. No resolution is in sight.



Water Water Everywhere, But Is It Safe to Drink?



In the time it takes you to read this map, say twenty minutes, 90 children around the world will have died because they didn't have enough clean water or sanitation facilities. In one day 9,300 people will have perished from diarrhea, cholera, schistosomiasis, and other diseases spread by contaminated water or the lack of water for adequate hygiene. By the end of the year 3.4 million will be gone. Most will have lived in Asia and Africa, and most will have been under age five. Though clean potable water is necessary for life and, some argue, is a basic human right, it is becoming harder to find due to pollution and the demands of a growing population. Even industrial nations are not immune. U.S. utilities will have to spend 1.5 billion dollars annually for 20 years to remove groundwater contaminants—everything from bacteria to atrazine, a common herbicide—while half the wells that supply affluent Santa Monica, California, have been closed because of high levels of MTBE, a gasoline additive. Especially troubling is the poisoning of aquifers—the primary source of drinking water for half the U.S. and nearly a third of the world. Unlike rivers, which renew themselves about every 20 days, aquifers can take hundreds of thousands of years to recharge.

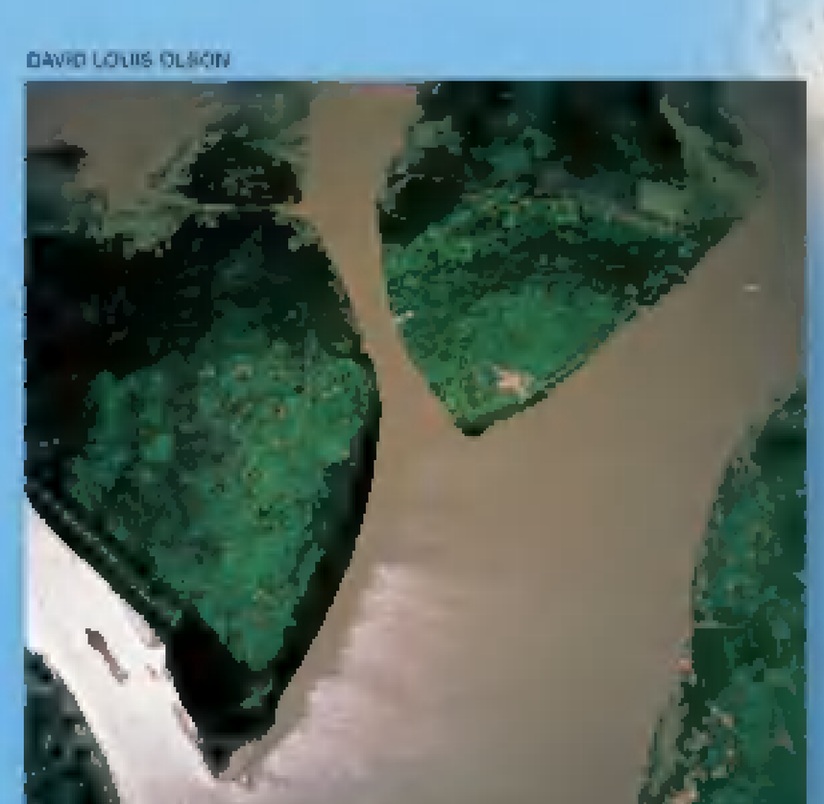
Design: Sally S. Summerall. Research: Linda R. Kriete. Edit: Maureen J. Flynn. GIS: Windy A. Robertson. Production: John S. Bailey, Dianne C. Hunt, Meghan M. Kieffer. Text: Joel Bourne, author; Robin A. Palmer, researcher

Interrupted Goode Homolosine Projection
SCALE: 1:63,360,000 or 1 INCH = 1000 MILES

PRIMARY WATERSHEDS

Watersheds are the Earth's rain barrels, catching precipitation that falls on land and channeling it to streams, rivers, aquifers, and lakes. Along the way watersheds filter pollutants and provide water for farms, industries, and households. Many major watersheds are now stressed by human activities.

Annual Renewable Water (cubic meters per person, 1995)
- More than 10,000
- 4,000-10,000
- 1,700-4,000
- 1,000-1,700
- Fewer than 1,000
- Critical area
- Dam

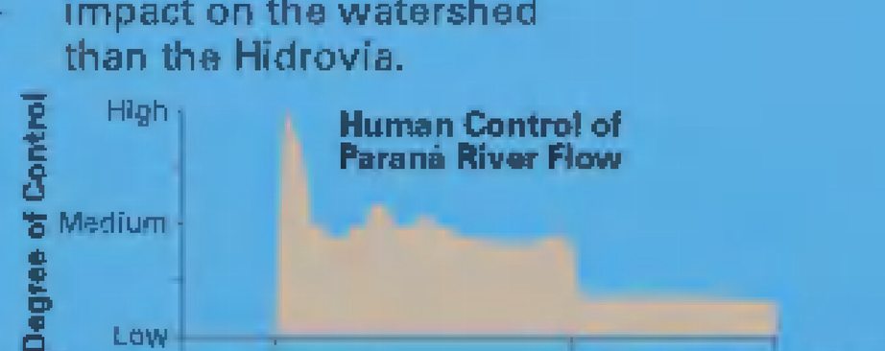


The Paraná River Delta (left) splits into 1,200 streams before it empties into the Río de la Plata just north of Buenos Aires.

PARANÁ RIVER BASIN—River or Canal?

PARANÁ WATERSHED AREA 997,175 sq mi (2,582,672 sq km); URBAN GROWTH RATE 2%; POPULATION DENSITY 70 per sq mi (27 per sq km); LARGE CITIES 54

Politicians have dreamed of a navigable waterway through the heart of South America for more than a century. Despite environmental concerns, it may soon be a reality. The multinational Hidrovía project plans to turn the winding Paraná River and its main tributary, the Paraguay River, into a barge canal funneling minerals and crops from landlocked areas of Brazil, Bolivia, Paraguay, Uruguay, and Argentina to ports on the Atlantic coast. But the project could also drain a significant portion of the Pantanal, the world's largest contiguous wetland. Home to hundreds of species dependent on seasonal flooding—some rare—the Pantanal is also a key component of the continent's hydrologic cycle. The Hidrovía project is mired in controversy, with Brazil suspending work on it. But other countries along the route continue to dredge and straighten the channel. Scientists worry that such a piecemeal approach could have an even greater impact on the watershed than the Hidrovía.



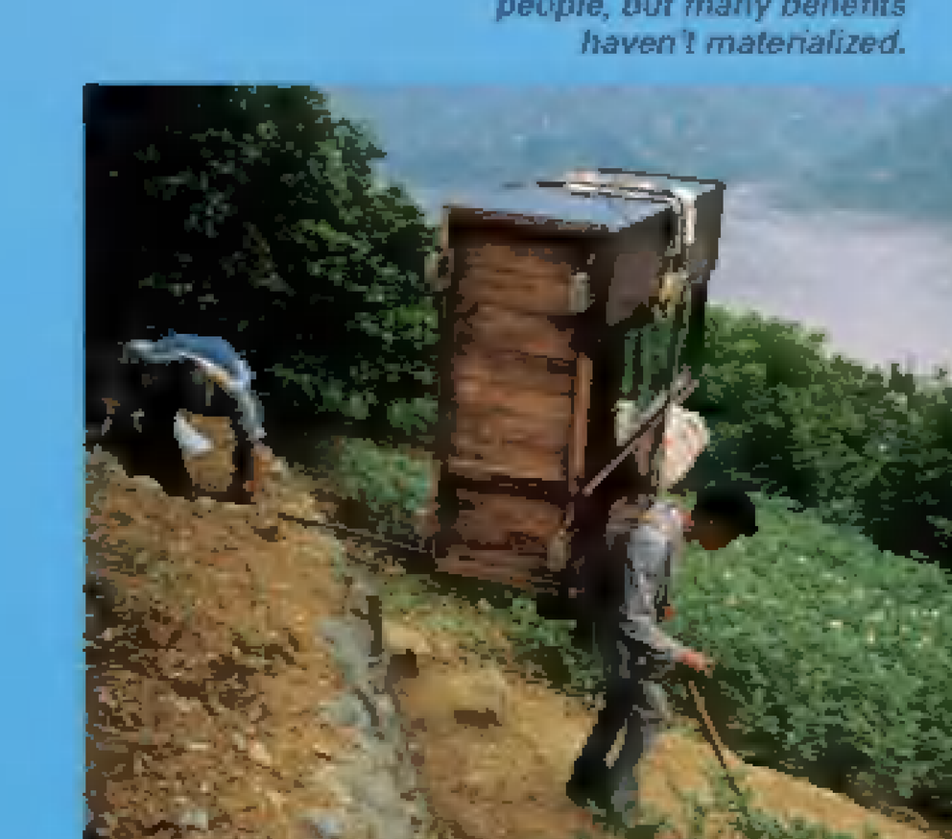
Residents of towns on the shore of Lake Chad, like this Cameroon village, depend on the lake's declining fish stocks to help them survive the region's ongoing drought.

LAKE CHAD—Africa's Vanishing Lake

LAKE CHAD WATERSHED AREA 964,452 sq mi (2,497,916 sq km); URBAN GROWTH RATE 4.7%; POPULATION DENSITY 31 per sq mi (12 per sq km); LARGE CITIES 3

When natural phenomena and population pressures combine on a watershed, the results can be tragic. Such is the case of Lake Chad. In 1962 it was the fourth largest water body on the continent, a shallow 9,600-square-mile expanse tucked between the Sahara and the rain forests of central Africa. Now it's shrunk to a 20th of that size. Persistent drought since the late 1960s led to overgrazing of surrounding grasslands, which some scientists speculate may have exacerbated the drought. A large-scale irrigation project designed to distribute water from the lake failed when the lake's level dropped below the intake location. Today some farmers successfully grow crops such as rice, wheat, and corn in polders, low-lying areas where the lake has receded and the soil is moist. But for others of the area's 20 million residents, food supplies are tight—and growing tighter.

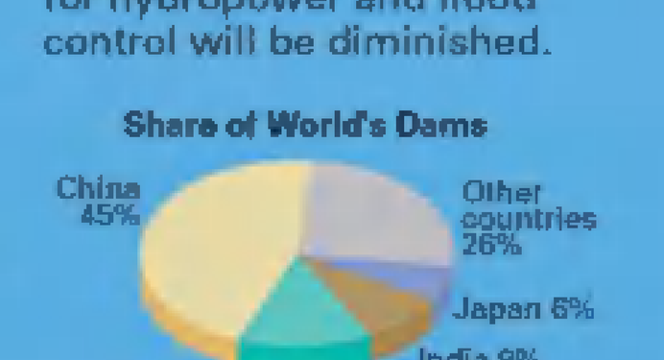
A family moves to make room for the Three Gorges Dam. Leaders promised new homes, schools, and jobs for displaced people, but many benefits haven't materialized.



YANGTZE RIVER BASIN—Monumental Gamble

YANGTZE WATERSHED AREA 664,928 sq mi (1,722,155 sq km); URBAN GROWTH RATE 2.4%; POPULATION DENSITY 549 per sq mi (212 per sq km); LARGE CITIES 56

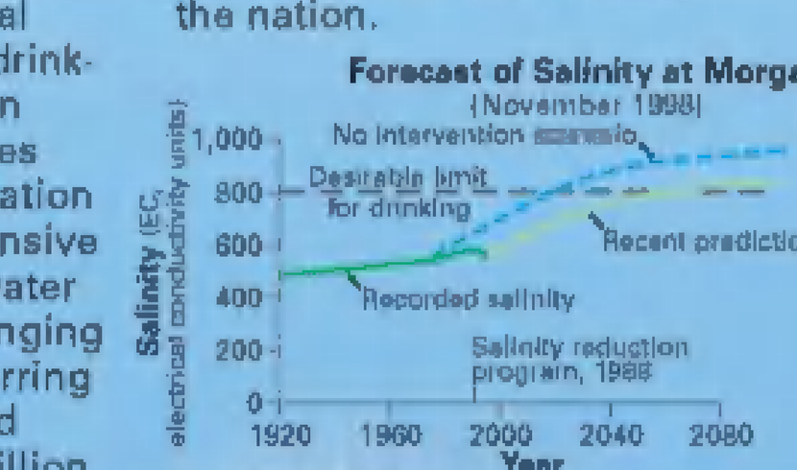
The concrete is poured, the cofferdam holding back the mighty Yangtze has been torn away, and the murky water is gathering behind the largest man-made edifice built in China since the Great Wall: Three Gorges Dam. Beijing's leaders believe the dam will cure many of the nation's ills, taming lethal floods while generating jobs, commerce, and a ninth of China's electricity. To its legion of critics the 1.3-mile-long, 600-foot-high monolith is a 25-billion-dollar environmental nightmare. It will displace nearly two million people, inundate some of China's best farmland, and create a 370-mile-long lake that critics say will fill with a billion tons of sewage and industrial wastes each year. The Yangtze will be the final arbiter. If the river's silt builds behind the dam, its capacity for hydropower and flood control will be diminished.



MURRAY-DARLING WATERSHED—Salty Soils

MURRAY-DARLING WATERSHED AREA 405,450 sq mi (1,050,111 sq km); URBAN GROWTH RATE 0.5%; POP. DENSITY 5 per sq mi (2 per sq km); LARGE CITIES 2

The Murray-Darling basin waters Australia's breadbasket. It covers one-seventh of the country, producing 41 percent of agricultural income and supplying drinking water for two million people. But two centuries of clearing native vegetation for agriculture and extensive irrigation have raised water tables in the region, bringing the soil's naturally occurring salts into root zones and rivers. More than 1.6 million acres are seriously affected by salt. That could spread to nearly 8.4 million acres by 2050, despite salt-reduction projects built to protect the rivers. Basin salinization costs Australia more than 170 million dollars (U.S.) a year in water treatment and lost productivity—leading officials to call it the most important environmental issue facing the nation.



Trees wither in a disposal pond for salty groundwater—caused by years of irrigation—that threatens Australia's Murray River. Such efforts have slowed the river's rising salinity.

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A World Transformed

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Washington, D.C., September 2002

The hole in Earth's protective ozone layer (shown in blue above Antarctica) grew to the size of North America in 2001. Scientists predict it will start to shrink in 30 to 50 years as ozone-depleting chemicals are removed from the atmosphere.
NASA GODDARD SPACE FLIGHT CENTER, SCIENTIFIC VISUALIZATION STUDIO

When humans emerged in Africa some two million years ago, their impact on the continent, teeming with wildlife, was pretty small. Slowly over the course of time, they evolved the capacity to learn—their brains enlarging as they developed tools, agriculture, and civilizations, until they stood poised to change the planet. Today *Homo sapiens* is one of the most pervasive species on Earth, 6.2 billion strong and growing by 80 million a year. Human impacts on the landscape are global in scale, on a par with volcanism or tectonic shifts. New data combining satellite imagery with historical records reveal that humans have planted, grazed, paved, or built upon roughly 40 percent of the Earth's terrestrial surface. This has led to profound changes in the atmosphere, soils, and oceans. No place remains untouched.

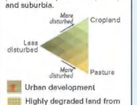
Population, consumption, and technology are seen by many experts as driving the human impact on the planet. One hopeful sign: Fertility rates have fallen sharply in the developing world (from about six births per woman in the 1960s to around three today) due to increased education, lower infant mortality, and greater access to contraceptives. As a result, world population may reach only nine billion by 2050 instead of the ten billion predicted just a few years ago. It may even begin to decline soon after. The bad news is that the population of the 48 poorest countries is still expected to triple in the next 50 years. Half the developing world lives on less than two dollars a day, yet consumption—and expectations for a better life—continues to rise.

Our large brains got us to this point. The question now is, can they get us out?

SURFACE TENSION: PEOPLE, PROGRESS, PRESSURE

HUMAN IMPACT

New data show how humans have transformed the face of the Earth from virgin forests and grasslands to croplands, pastures, tree plantations, cities, and suburbs.



Urban development
Highly degraded land from agriculture or overgrazing

World's largest cities
- 1-5 million
- 5-10 million
- Megacity over 10 million

GLOBAL ENERGY

Oil supplies 40 percent of the world's energy, yet two-thirds of known reserves lie in five Persian Gulf countries. Alternative energy sources are widespread—though largely untapped.

Regions with largest reserves
- Coal
- Natural gas
- Oil

Countries leading in renewable energy use
- Geothermal
- Hydroelectric
- Solar
- Wind

NATURE'S HABITATS

Nearly 10 percent of Earth's land area is protected as parks and preserves: together a sanctuary larger than Antarctica. Yet much of that area remains threatened by logging, poaching, or mining.

- Major protected area (natural reserve, wildlife sanctuary, national park, or natural monument)
- Natural World Heritage site
- Natural World Heritage site in danger
- Threatened frontier forest
- Countries or regions with increasing forest area
- Soil and water conservation (widespread use of erosion-prevention techniques)

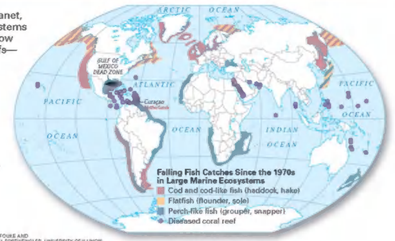
COASTAL ZONES

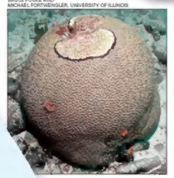
Two of every five people on the planet live less than 68 miles from a coast. Their impact has been profound. More than half the world's coastline is threatened by future development.

- Coral reef
- Coral reef biodiversity hotspot (threatened area)
- Dead zone (oxygen-starved water)
- Mangrove
- Marine protected area

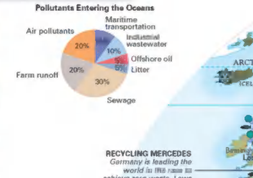
Oceans at Risk

Although they cover two-thirds of the planet, oceans are the least understood ecosystems and likely the most at risk. What we know is sobering. Nearly 60 percent of coral reefs—vital sources of biodiversity and marine productivity—are threatened by human actions; a fourth of those are already degraded beyond recovery. Some 70 percent of major commercial fish stocks are depleted, overfished, or exploited beyond maximum sustainable yield. Ocean pollution is on the rise, including industrial wastes, pesticides, and sewage. In addition, eroded soil and fertilizers have spawned 50 known dead zones around the globe, including a massive one in the Gulf of Mexico.



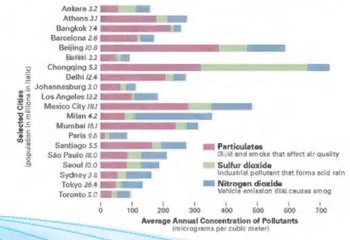

BRUCE FOURE AND MICHAEL FORTNERGLER, UNIVERSITY OF ILLINOIS

Black band disease kills a coral head near Curaçao. Linked to pollution, the disease is driving reef loss.



The Air We Breathe

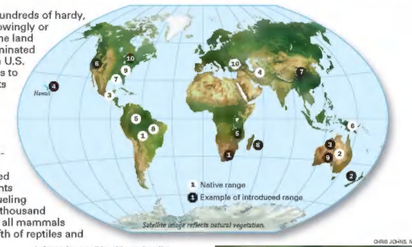
For millions of people around the world, simply breathing has become risky business. An estimated three million people die annually from the effects of pollutants—sulfur dioxide, nitrogen dioxide, particulates, and ozone, among others—that result from the burning of fossil fuels. Children in the developing world's megacities are the hardest hit, often inhaling two to eight times the amount of pollutants deemed safe by the World Health Organization.



HOT WASTE
The Cold War left a deadly legacy in this former Soviet Union, where plutonium plants routinely dumped radioactive waste in rivers, lakes, and the Arctic Ocean.

Alien Invasion

Earth is quickly being taken over by hundreds of hardy, aggressive species spread either knowingly or accidentally by human hands. Half the land area of Hawaii, for example, is now dominated by alien species. Such invaders cost the U.S. nearly 140 billion dollars a year in losses to agriculture, forestry, and other segments of the economy. Spiraling global trade is partly to blame. An estimated 3,000 marine species hitch rides every day in the ballast water of cargo ships. Many of the invaders, such as the prolific zebra mussel, have the potential to catastrophically alter the ecosystems they invade. Alien species are now considered the second greatest threat to native plants and animals after habitat destruction, fueling extinction rates that are a hundred to a thousand times greater than normal. A quarter of all mammals and fish are now threatened, as are a fifth of reptiles and amphibians, and a tenth of all birds.



1. **Argentine ant** (*Linepithema humile*)
Aggressive colonizer that displaces native birds
2. **Brushtail possum** (*Trichosurus vulpecula*)
Highly destructive leaf-eating marsupial
3. **Cane toad** (*Bufo marinus*)
Displaces native amphibians
4. **Indian mongoose** (*Herpestes auropunctatus*)
Threatens native bird populations
5. **Water hyacinth** (*Eichhornia crassipes*)
Chokes waterways, reducing species
6. **Phytophthora root rot** (*Phytophthora cinnamomi*) Fungus that kills numerous plants
7. **Red-eared slider turtle** (*Trachemys scripta*)
Pet-trade turtle that feeds on many native species
8. **Strawberry guava** (*Psidium cattleianum*)
Invasive shrub that displaces local vegetation
9. **Western mosquito fish** (*Gambusia affinis*)
Predatory fish introduced to control mosquitoes
10. **Zebra mussel** (*Dreissena polymorpha*)
Clogs pipes and displaces native mollusks

CHRIS JOHNS, NGS

Introduced to Hawaii in the 1800s to kill rats in sugarcane fields, the Indian mongoose has since wreaked havoc on native birds and poultry. It causes millions of dollars in damages to domestic flocks and ground-nesting birds in Hawaii each year.

Design: Sally S. Summerall. Research: Kristine L. French. Edit: David B. Miller. GIS: Jan B. Morris. Production: John S. Bailey, Stephan P. Wells, Tanya Joel K. Bourne, Jr., author; Barbara W. McConnell, researcher.

Main map sources. Global cropland, pasture, and urban data: Jonathan A. Foley, Navin Ramankutty, Center for Sustainability and the Global Environment, University of Wisconsin; International Food Policy Research Institute, Population graph: UN World Population Prospects (2000 rev.), and World Urbanization Prospects (2001 rev.), esa.un.org/unpp; Highly degraded land: Global Assessment of Human Induced Soil Degradation (GLASOD), International Soil Reference and Information Centre; UN Environment Programme (UNEP), Protected areas, coral reefs, and mangroves: UNEP World Conservation Monitoring Centre, World Heritage sites: UNESCO, Soil conservation: World Overview of Conservation Approaches and Technologies. Threatened frontier forests: World Resources Institute (WRI). Coral reef biodiversity hotspots: Center for Applied Biodiversity Science, Conservation International; C. M. Roberts et al., Science, vol. 295, Feb. 15, 2002. Dead zones: Burke et al., Pilot Analysis of Global Ecosystems (2000)

Inset map sources. Large marine ecosystems: Kenneth Sherman, NOAA; Fish decline data: Villy Christensen, Reg Watson, Daniel Pauly, Sea Around Us Project, University of British Columbia. Ocean pollution chart, Global Programme of Action, UNEP. Air pollution graph: 2001 World Development Indicators, World Bank. Alien species: Global Invasive Species Programme. Habitats and global warming: Jay K. Malcolm, University of Toronto; Adam Markham, Lara Hansen, World Wildlife Fund. Energy statistics: U.S. Department of Energy. Frontier forests: Dirk Bryant, Global Forest Watch, WRI. Soil degradation data: GLASOD

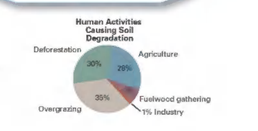
Interrupted Goode Homolosine Projection
SCALE: 1:49,611,000 or 1 INCH = 783 MILES

Earth's Vulnerable Soils

Six to eight inches of topsoil is all that stands between much of the world and starvation. Yet each year a huge swath of agricultural land is lost to erosion, salinization, and other forms of soil degradation. Less topsoil means less food: Degraded soils have lowered global yields by 13 percent since World War II. Soil scientist Hari Eswaran, chair of an international working group on land degradation, calls it "the root of all socioeconomic problems" in developing nations.

JIM RICHARDSON

Contour strip-cropping on farms in Wisconsin's Coon Creek watershed led to a 75 percent decline in soil erosion.



Missing the Forests for the Trees

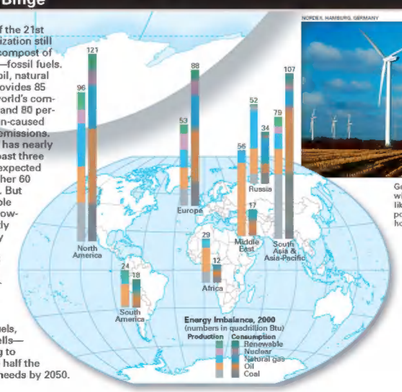
Forests are the lungs of the planet, capturing vast amounts of carbon dioxide, releasing oxygen, and protecting soil, fresh water, and up to 90 percent of all terrestrial species in the bargain. Yet humans continue to mow down forests as if they were lawns. Half the forests that stood 8,000 years ago have been destroyed—much of them during the past 400 years—while only a fifth remain in large undisturbed tracts. Each year the world cuts an area larger than Florida, with the greatest rates of deforestation occurring in South America, Africa, and Southeast Asia. Forests are such massive reservoirs of carbon that their loss in the tropics alone released about a fifth of all human-caused carbon dioxide emissions in the past decade.


B. G. TOGU MANURUNG

This Sumatran rain forest was cleared for a timber or oil-palm plantation, part of the 3.2 million acres cut in Indonesia each year. Seventy percent of the logs processed in Indonesia are illegally obtained.

Energy Binge

At the dawn of the 21st century, civilization still runs on the compost of the distant past—fossil fuels. The burning of oil, natural gas, and coal provides 85 percent of the world's commercial energy, and 80 percent of all human-caused carbon dioxide emissions. Energy demand has nearly doubled in the past three decades and is expected to increase another 60 percent by 2020. But cleaner renewable energy use is growing fast. Currently supplying nearly 10 percent of the world's total energy (mostly from hydropower), alternative sources—wind turbines, solar cells, biomass fuels, hydrogen fuel cells—could, according to studies, provide half the world's energy needs by 2050.



NORDEX, HAMBURG, GERMANY

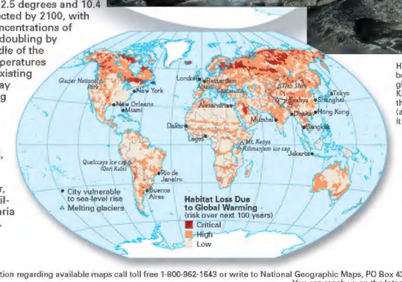
Germany leads the world in wind energy. Modern turbines like these produce enough power for five million European homes.

A Warmer World

Most scientists agree that the planet is warming and that humans—with our greenhouse-gas-emitting power plants, cars, and factories—are a major reason. The average surface temperature rose 1 degree F last century. An additional rise of between 2.5 degrees and 10.4 degrees is projected by 2100, with atmospheric concentrations of carbon dioxide doubling by around the middle of the century. As temperatures rise, a third of existing land habitats may vanish, including half the boreal forests. There may be no sugar maples in New England, and, with mild mosquito-friendly weather, there may be millions more malaria cases each year.

LONNIE G. THOMPSON (BELOW); KEITH MOUNTAIN (RIGHT)

High-altitude glaciers appear to be among the first victims of global warming. Peru's Qori Kalis glacier retreated more than 2,700 feet between 1983 (above left) and 2001 (above). It could vanish entirely by 2020.



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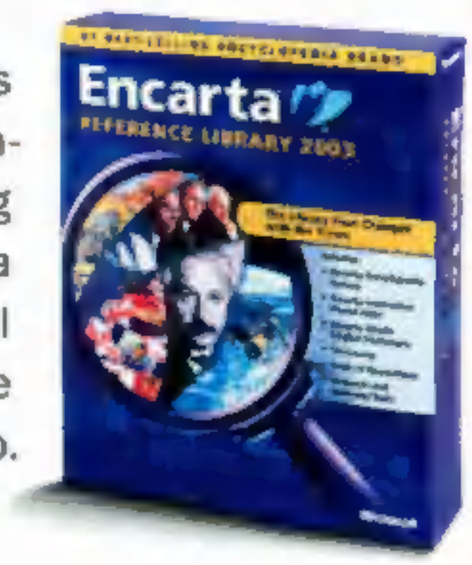

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VOL. 202 • NO. 3 • SEPTEMBER 2002

Contents

Water Pressure—2

FEATURES

DEPARTMENTS

THE COVER

The remains of a millipede hang from the mouth of a meerkat in the Kalahari Desert. Long claws dig up bugs, lizards, and other treats.
BY MATTIAS KLUM

ON THE NGM WEBSITE

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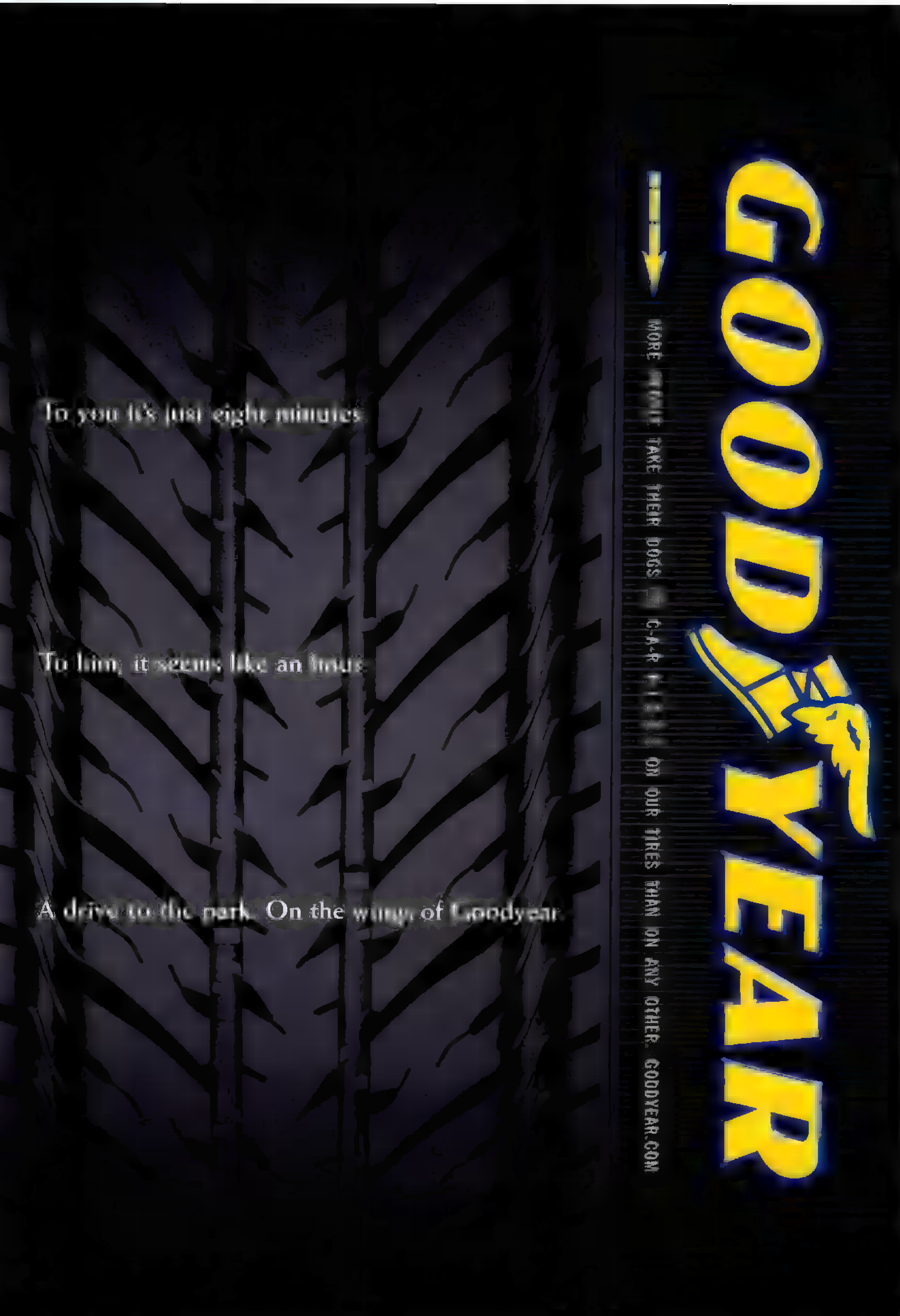
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From the Editor

I'm sitting on a forested hillside on the Hawaiian island of Molokai. An arbor of green surrounds me—eucalyptus, ironwood, and Christmasberry. Last night I heard the barking sound of an axis deer. It's paradise.

Or is it? Nearly all the plants around me are invasive aliens—species humans have brought to Hawaii, where they've reproduced nearly unchecked, pushing hundreds of native species toward extinction. Even the deer, imports from India, are a problem. Like the introduced feral pigs and goats, they're tearing up the place. Erosion from hills stripped by grazing has washed away soil. All that runoff has smothered coral reefs.

So even here, on the world's most remote island group, we've mucked things up. Yes, Hawaii's apparent health is an illusion, but how many visitors know that? If we hope to preserve a small part of the planet's natural wealth, we need more information.

In January NATIONAL GEOGRAPHIC introduced the first in a series of articles called Hotspots—close-up looks at some of the most species-rich places on Earth. This month you'll find "State of the Planet," a checkup on the condition of the environment ten years after the Earth Summit in Rio de Janeiro.

How well have governments acted upon the recommendations proposed at the summit a decade ago? There have been successes, but if I were issuing the report card from my cozy, relatively lovely island perch, it would read "Try harder."

Bill Allen

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good ideas are growing

Forum

May 2002

Moths rule. Lynne Warren's article on Joseph Scheer's digital moth prints generated more letters than any other piece in the May issue. Most readers wanted to know how to buy a print. You can get them directly from the artist by contacting him at fscheer@alfred.edu. Williard Home Products, a Missouri company that makes mothballs, has already ordered 11 prints for the office.

FOOD
How Safe? How Altered?

I find it very ironic that the first argument biotech corporations and university researchers use to justify genetically altered food is the great benefit it will bring to people in developing nations. Are we supposed to believe that these new million-dollar food technologies are going to be made available to the poorest of the poor? A more likely scenario is that these foods will be expensive novelty items in American and European supermarkets.

AKEIA BENARD
Providence, Rhode Island

It should be noted that the so-called greedy, evil Monsanto Company did a lot of the research on developing disease-resistant sweet potatoes for Africans at no cost (at least to the people who use the vegetables). Before we condemn the industrial agricultural community, we should realize that a lot of profit gets plowed back into useful research, and without that money not a whole lot is going to be accomplished.

H. WILLIAMS BARNES
Warrington, Pennsylvania

You mentioned that Sweden has almost eliminated *Salmonella* in chicken by improving the cleanliness of processing. Why can't we have as good government inspection here in the United States? The answer, I believe, lies in the large amounts of money that flow from the chemical and drug companies into the campaign funds of senators and representatives. It also appears that the U.S. Department of Agriculture is interested in protecting Monsanto and drug companies instead of farmers and consumers.

AUGUSTIN H. PARKER
Marblehead, Maine

I raise beef cattle, cotton, and grain on a small family farm in southeast Texas. When slaughterhouse workers have only a few seconds to process a chicken or complete a step in the slaughter of a steer, naturally mistakes are going to be made, and fecal contamination is going to be high. Instead of shortening workers' shifts or slowing the processing rate, these companies invest heavily in everything from

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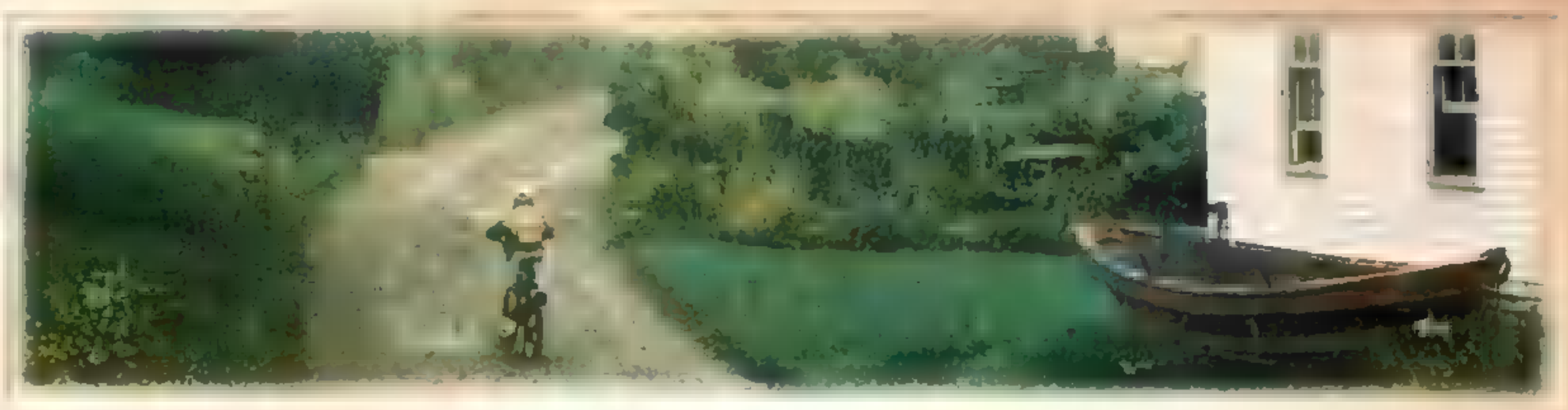

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Geographica: Land Mines

It is in style to advocate the banning of land mines. Have you ever spoken to a former U.S. soldier who was waiting to participate in the invasion of Japan when the atomic bombs were dropped? Some soldiers say the bombs probably saved their lives. Napalm was the poster-child bad weapon during Vietnam. I remember as an infantryman in that conflict watching the greasy black smoke rising and thinking, Do it again. I don't know if napalm saved my life, but it may have. When a nation sends its young men into combat, it has an obligation to provide every tool that might bring them home alive. All the bad things said about land mines are true—they linger long after a conflict is over, and they often kill or maim the innocent. But should soldiers be sent into combat unarmed? It is better that politicians avoid armed conflict.

PETER HAYDEN
Manchester, Missouri

PAUL HANSEN

Land mines are truly insidious—cheap to make and easy to distribute but difficult to detect and expensive to remove. Last year I co-produced *Aftermath: The Remnants of War.* The final section of the documentary profiles the Balkan conflict. Three weeks after we returned from filming in Sarajevo, we learned that one of our guides, a young deminer from Sweden, had been killed along with two local colleagues by a land mine in a booby-trapped body. Though the Mine Ban Treaty was a monumental step forward, we still have far to go. The fact that major world powers such as China, the U.S., and Russia are not signatories undermines the effectiveness of the treaty.

ED BARREVELD
Toronto, Ontario

irradiation to chemical baths to solve a problem that could have been mitigated by more time and more careful work.

JEFF ROBERTS
Needville, Texas

Food irradiation is 100 percent effective against microbes and pathogens such as *E. coli.* It is commercially available, has been in use for years, and has undergone exhaustive testing. Nevertheless, the antinuclear press and education establishment continue their paranoia and fear campaign to prevent widespread adoption. This borders on criminal negligence. How many victims of curable threats do we have to have?

HARLAN SNYDER
Saratoga, California

You write that Canada hasn't approved the use of recombinant bovine growth hormone, but you didn't say why. Canadian scientists and doctors found there was compelling evidence that called its safety into question. Same for the European Union. The hormone dramatically increases the rate of mastitis in cows, which increases the need for antibiotics—which means more antibiotic residue in milk.

ROXANNE NELSON
Seattle, Washington

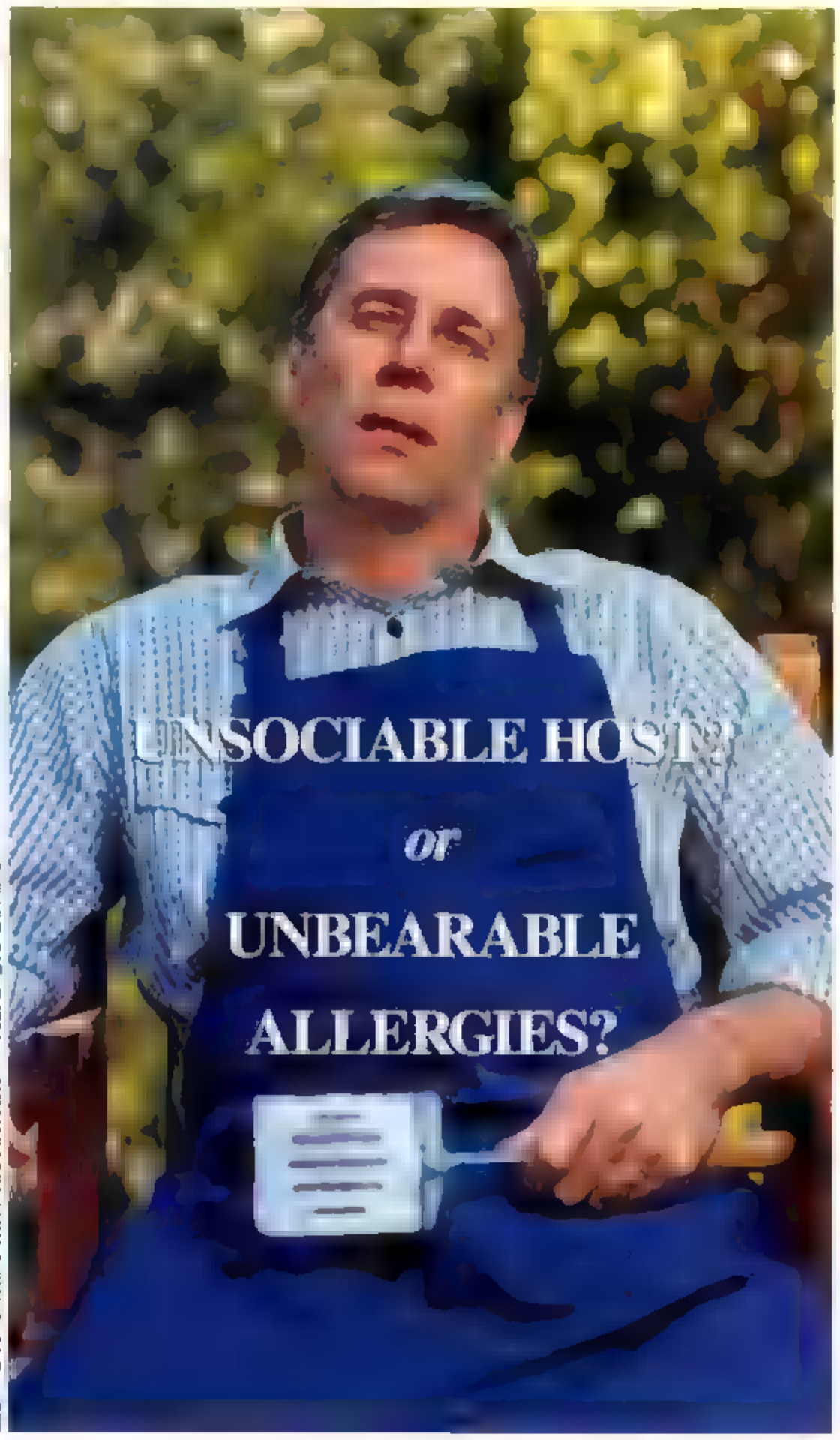
I'm a 40-year researcher of food safety. Your articles on food were loaded with innuendos and rhetorical questions intended to evoke fear. They focus on the dangers of eating without considering that many people in the U.S., and many more in other countries, are constantly subjected to the dangers of *not* eating. The estimate of 5,000 deaths from foodborne diseases in the U.S. should be compared with the 4,000 deaths from malnutrition here in the richest country in the world. The false quest for absolute safety will further inflate food prices and increase the number of malnourished here. Longing for the good old days of rustic agriculture will only condemn more people to starve.

DEAN O. CLIVER
Davis, California

Your statement that "aggression costs the hog industry billions" sounds as if it was taken directly from a hog factory publication. No explanation is offered as to why these poor farm animals show such aggressive behavior. Pigs in hog factories are confined and treated brutally. The solution

WRITE TO FORUM

National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199, or by fax to **202-828-5460,** or via the Internet to **ngsforum@nationalgeographic.com.** Include name, address, and daytime telephone. Letters may be edited for clarity and space.



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Please see additional important information on next page.

Brief Summary of Prescribing Information as of November 2000

ALLEGRA®

(fexofenadine hydrochloride)

Capsules and Tablets

INDICATIONS AND USAGE

Seasonal Allergic Rhinitis

ALLEGRA is indicated for the relief of symptoms associated with seasonal allergic rhinitis in adults and children 6 years of age and older. Symptoms treated effectively were sneezing, rhinorrhea, itchy nose/palate/throat, itchy/watery/red eyes.

Chronic Idiopathic Urticaria

ALLEGRA is indicated for treatment of uncomplicated skin manifestations of chronic idiopathic urticaria in adults and children 6 years of age and older. It significantly reduces pruritus and the number of wheals.

CONTRAINDICATIONS

ALLEGRA is contraindicated in patients with known hypersensitivity to any of its ingredients.

PRECAUTIONS

Drug Interaction with Erythromycin and Ketoconazole

Fexofenadine hydrochloride has been shown to exhibit minimal (ca. 5%) metabolism. However, co-administration of fexofenadine hydrochloride with ketoconazole and erythromycin led to increased plasma levels of fexofenadine hydrochloride. Fexofenadine hydrochloride had no effect on the pharmacokinetics of erythromycin and ketoconazole. In two separate studies, fexofenadine hydrochloride 120 mg twice daily (two times the recommended twice daily dose) was co-administered with erythromycin 500 mg every 8 hours or ketoconazole 400 mg once daily under steady-state conditions to normal, healthy volunteers (n=24, each study). No differences in adverse events or QT_c interval were observed when patients were administered fexofenadine hydrochloride alone or in combination with erythromycin or ketoconazole. The findings of these studies are summarized in the following table:

Effects on steady-state fexofenadine hydrochloride pharmacokinetics after 7 days of co-administration with fexofenadine hydrochloride 120 mg every 12 hours (two times the recommended twice daily dose) in normal volunteers (n=24)

Concomitant Drug	$C_{max,SS}$ *(Peak plasma concentration)*	$AUC_{SS(0-12h)}$ *(Extent of systemic exposure)*
Erythromycin (500 mg every 8 hrs)	+82%	+109%
Ketoconazole (400 mg once daily)	+135%	+164%

The changes in plasma levels were within the range of plasma levels achieved in adequate and well-controlled clinical trials.

The mechanism of these interactions has been evaluated in *in vitro*, *in situ*, and *in vivo* animal models. These studies indicate that ketoconazole or erythromycin co-administration enhances fexofenadine gastrointestinal absorption. *In vivo* animal studies also suggest that in addition to increasing absorption, ketoconazole decreases fexofenadine hydrochloride gastrointestinal secretion, while erythromycin may also decrease biliary excretion.

Drug Interactions with Antacids

Administration of 120 mg of fexofenadine hydrochloride (2 x 60 mg capsule) within 15 minutes of an aluminum and magnesium containing antacid (Maalox®) decreased fexofenadine AUC by 41% and C_{max} by 43%. ALLEGRA should not be taken closely in time with aluminum and magnesium containing antacids.

Carcinogenesis, Mutagenesis, Impairment of Fertility

The carcinogenic potential and reproductive toxicity of fexofenadine hydrochloride were assessed using terfenadine studies with adequate fexofenadine hydrochloride exposure (based on plasma area-under-the-concentration vs. time [AUC] values). No evidence of carcinogenicity was observed in an 18-month study in mice and in a 24-month study in rats at oral doses up to 150 mg/kg of terfenadine (which led to fexofenadine exposures that were respectively approximately 8 and 5 times the exposure from the maximum recommended daily oral dose of fexofenadine hydrochloride in adults and children).

In *in vitro* (Bacterial Reverse Mutation, CHO/HGPRT Forward Mutation, and Rat Lymphocyte Chromosomal Aberration assays) and *in vivo* (Mouse Bone Marrow Micronucleus assay) tests, fexofenadine hydrochloride revealed no evidence of mutagenicity.

In rat fertility studies, dose-related reductions in implants and increases in postimplantation losses were observed at an oral dose of 150 mg/kg of terfenadine (which led to fexofenadine hydrochloride exposures that were approximately 8 times the exposure of the maximum recommended daily oral dose of fexofenadine hydrochloride in adults).

Pregnancy

Teratogenic Effects: Category C. There was no evidence of teratogenicity in rats or rabbits at oral doses of terfenadine up to 300 mg/kg (which led to fexofenadine exposures that were approximately 4 and 31 times, respectively, the exposure from the maximum recommended daily oral dose of fexofenadine in adults).

There are no adequate and well controlled studies in pregnant women. Fexofenadine should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Nonteratogenic Effects. Dose-related decreases in pup weight gain and survival were observed in rats exposed to an oral dose of 150 mg/kg of terfenadine (approximately 3 times the maximum recommended daily oral dose of fexofenadine hydrochloride in adults based on comparison of fexofenadine hydrochloride AUCs).

Nursing Mothers

There are no adequate and well-controlled studies in women during lactation. Because many drugs are excreted in human milk, caution should be exercised when fexofenadine hydrochloride is administered to a nursing woman.

Pediatric Use

The recommended dose in patients 6 to 11 years of age is based on cross-study comparison of the pharmacokinetics of ALLEGRA in adults and pediatric patients and on the safety profile of fexofenadine hydrochloride in both adult and pediatric patients at doses equal to or higher than the recommended doses.

The safety of ALLEGRA tablets at a dose of 30 mg twice daily has been demonstrated in 438 pediatric patients 6 to 11 years of age in two placebo-controlled 2-week seasonal allergic rhinitis trials. The safety of ALLEGRA for the treatment of chronic idiopathic urticaria in patients 6 to 11 years of age is based on cross-study comparison of the pharmacokinetics of ALLEGRA in adult and pediatric patients and on the safety profile of fexofenadine in both adult and pediatric patients at doses equal to or higher than the recommended dose.

The effectiveness of ALLEGRA for the treatment of seasonal allergic rhinitis in patients 6 to 11 years of age was demonstrated in one trial (n=411) in which ALLEGRA tablets 30 mg twice daily significantly reduced total symptom scores compared to placebo, along with extrapolation of demonstrated efficacy in patients ages 12 years and above, and the pharmacokinetic comparisons in adults and children. The effectiveness of ALLEGRA for the treatment of chronic idiopathic urticaria in patients 6 to 11 years of age is based on an extrapolation of the demonstrated efficacy of ALLEGRA in adults with this condition and the likelihood that the disease course, pathophysiology and the drug's effect are substantially similar in children to that of adult patients.

The safety and effectiveness of ALLEGRA in pediatric patients under 6 years of age have not been established.

Geriatric Use

Clinical studies of ALLEGRA tablets and capsules did not include sufficient numbers of subjects aged 65 years and over to determine whether this population responds differently from younger patients. Other reported clinical experience has not identified differences in responses between the geriatric and younger patients. This drug is known to be substantially excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function. Because elderly patients are more likely to have decreased renal function, care should be taken in dose selection, and may be useful to monitor renal function. (See CLINICAL PHARMACOLOGY).

ADVERSE REACTIONS

Seasonal Allergic Rhinitis

Adults. In placebo-controlled seasonal allergic rhinitis clinical trials in patients 12 years of age and older, which included 2461 patients receiving fexofenadine hydrochloride capsules at doses of 20 mg to 240 mg twice daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. All adverse events that were reported by greater than 1% of patients who received the recommended daily dose of fexofenadine hydrochloride (60 mg capsules twice daily), and that were more common with fexofenadine hydrochloride than placebo, are listed in Table 1.

In a placebo-controlled clinical study in the United States, which included 570 patients aged 12 years and older receiving fexofenadine hydrochloride tablets at doses of 120 or 180 mg once daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. Table 1 also lists adverse experiences that were reported by greater than 2% of patients treated with fexofenadine hydrochloride tablets at doses of 180 mg once daily and that were more common with fexofenadine hydrochloride than placebo. The incidence of adverse events, including drowsiness, was not dose-related and was similar across subgroups defined by age, gender, and race.

Table 1

Adverse experiences in patients ages 12 years and older reported in placebo-controlled seasonal allergic rhinitis clinical trials in the United States

Twice daily dosing with fexofenadine capsules at rates of greater than 1%

Adverse experience	*Fexofenadine 60 mg Twice Daily (n=679)*	*Placebo Twice Daily (n=671)*
Viral Infection (cold, flu)	2.5%	1.5%
Nausea	1.6%	1.5%
Dysmenorrhea	1.5%	0.3%
Drowsiness	1.3%	0.9%
Dyspepsia	1.3%	0.6%
Fatigue	1.3%	0.9%

Once daily dosing with fexofenadine hydrochloride tablets at rates of greater than 2%

Adverse experience	*Fexofenadine 180 mg once daily (n=283)*	*Placebo (n=293)*
Headache	10.6%	7.5%
Upper Respiratory Tract Infection	3.2%	3.1%
Back Pain	2.8%	1.4%

The frequency and magnitude of laboratory abnormalities were similar in fexofenadine hydrochloride and placebo-treated patients.

Pediatric. Table 2 lists adverse experiences in patients aged 6 to 11 years of age which were reported by greater than 2% of patients treated with fexofenadine hydrochloride tablets at a dose of 30 mg twice daily in placebo-controlled seasonal allergic rhinitis studies in the United States and Canada that were more common with fexofenadine hydrochloride than placebo.

Table 2

Adverse experiences reported in placebo-controlled seasonal allergic rhinitis studies in pediatric patients ages 6 to 11 in the United States and Canada at rates of greater than 2%

Adverse experience	*Fexofenadine 30 mg twice daily (n=209)*	*Placebo (n=229)*
Headache	7.2%	6.6%
Accidental Injury	2.9%	1.3%
Coughing	3.8%	1.3%
Fever	2.4%	0.9%
Pain	2.4%	0.4%
Otitis Media	2.4%	0.0%
Upper Respiratory Tract Infection	4.3%	1.7%

Chronic Idiopathic Urticaria

Adverse events reported by patients 12 years of age and older in placebo-controlled chronic idiopathic urticaria studies were similar to those reported in placebo-controlled seasonal allergic rhinitis studies. In placebo-controlled chronic idiopathic urticaria clinical trials, which included 726 patients 12 years of age and older receiving fexofenadine hydrochloride tablets at doses of 20 to 240 mg twice daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. Table 3 lists adverse experiences in patients aged 12 years and older which were reported by greater than 2% of patients treated with fexofenadine hydrochloride 60 mg tablets twice daily in controlled clinical studies in the United States and Canada and that were more common with fexofenadine hydrochloride than placebo. The safety of fexofenadine hydrochloride in the treatment of chronic idiopathic urticaria in pediatric patients 6 to 11 years of age is based on the safety profile of fexofenadine hydrochloride in adults and adolescent patients at doses equal to or higher than the recommended dose (see Pediatric Use).

Table 3

Adverse experiences reported in patients 12 years and older in placebo-controlled chronic idiopathic urticaria studies in the United States and Canada at rates of greater than 2%

Adverse experience	*Fexofenadine 60 mg twice daily (n=186)*	*Placebo (n=178)*
Back Pain	2.2%	1.1%
Sinusitis	2.2%	1.1%
Dizziness	2.2%	0.6%
Drowsiness	2.2%	0.0%

Events that have been reported during controlled clinical trials involving seasonal allergic rhinitis and chronic idiopathic urticaria patients with incidences less than 1% and similar to placebo and have been rarely reported during postmarketing surveillance include: insomnia, nervousness, and sleep disorders or paroniria. In rare cases, rash, urticaria, pruritus and hypersensitivity reactions with manifestations such as angioedema, chest tightness, dyspnea, flushing and systemic anaphylaxis have been reported.

OVERDOSAGE

Reports of fexofenadine hydrochloride overdose have been infrequent and contain limited information. However, dizziness, drowsiness, and dry mouth have been reported. Single doses of fexofenadine hydrochloride up to 800 mg (six normal volunteers at this dose level), and doses up to 690 mg twice daily for 1 month (three normal volunteers at this dose level) or 240 mg once daily for 1 year (234 normal volunteers at this dose level) were administered without the development of clinically significant adverse events as compared to placebo.

In the event of overdose, consider standard measures to remove any unabsorbed drug. Symptomatic and supportive treatment is recommended.

Hemodialysis did not effectively remove fexofenadine hydrochloride from blood (1.7% removed) following terfenadine administration.

No deaths occurred at oral doses of fexofenadine hydrochloride up to 5000 mg/kg in mice (110 times the maximum recommended daily oral dose in adults and 200 times the maximum recommended daily oral dose in children based on mg/m²) and up to 5000 mg/kg in rats (230 times the maximum recommended daily oral dose in adults and 400 times the maximum recommended daily oral dose in children based on mg/m²). Additionally, no clinical signs of toxicity or gross pathological findings were observed. In dogs, no evidence of toxicity was observed at oral doses up to 2000 mg/kg (300 times the maximum recommended daily oral dose in adults and 530 times the maximum recommended daily oral dose in children based on mg/m²).

Prescribing Information as of November 2000

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FORUM

to the problem of pig aggression in hog factories lies in treating these animals more humanely, not in altering them genetically so the hog industry can increase its profits.

SUAT TUZLAK
Whitehorse, Yukon Territories

Are rigorous sanitizing regimes healthy? I don't believe they are. Getting sick may be necessary for the development of a healthy immune system. We humans have survived a heck of a long time without washing our hands regularly. Such practices may be weakening our immune systems to the point where, in the absence of bugs to fight, they look for other work to do. Many scientists think this causes allergies and asthma, which are increasing in the developed world.

HARRY MACHIELA
Napier, New Zealand

You may be right. The explanation many scientists have for this phenomenon is called the hygiene hypothesis. To learn more, read the new science page, Who Knew?, debuting in this issue.

I am a chef with a major hotel chain. I feel sad that Ms. Ackerman can never enjoy a perfect slice of rare *toro* tuna or spicy *capriccio*, not to mention a sublime oyster on the half shell. Life is filled with risk, but that is what makes it worth living.

WALTER C. HANNAH
Las Vegas, Nevada

Po River

The Europe that has openly criticized the U.S. for its rejection of the Kyoto Agreement is the same continent where major cities do not treat their effluent. I think that European environmentalists need to address the issue of water contamination with the same fervor they currently reserve for CO_2 emissions in the U.S. There is really no excuse for the level of water pollution found from Milan to Brussels, which continues to suffocate the waterways of Europe.

S. REILLY CELBA
Shorewood, Wisconsin

Inca Mummies

I'm disturbed by the increasing number of articles that feature the excavation and desecration of burial sites. I don't believe that we have an unlimited scientific right to dissect

Lou Gehrig's farewell: selfless

Fisk's game winner: timeless

Ripken's streak: endless

Bobby Thomson's winning homer: breathless

Willie Mays' World Series® catch: flawless

Aaron's 715th homer: peerless

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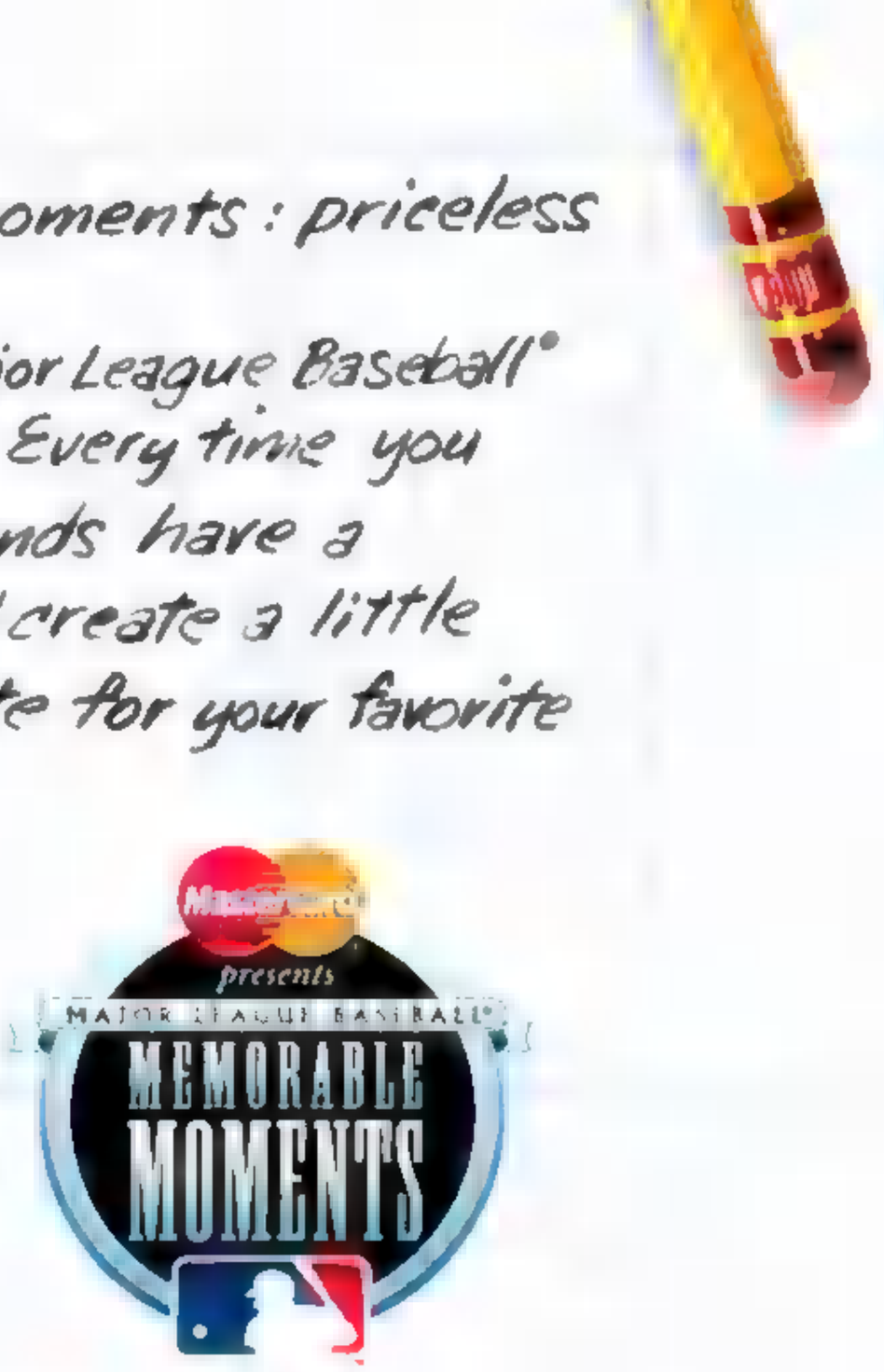

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MEMORABLE MOMENTS

Legal Notice

If You Are a Present or Past Owner or Operator of a Commercial, Governmental or Residential Building In the United States or Canada in Which Asbestos-Containing Products Are or Were Present, You May Have a Property Damage Claim Against the Following Entities (The "Debtors") in Bankruptcy Proceedings:

Federal-Mogul Corporation
T&N Limited
J.W. Roberts Limited
TAF International Limited

NOTE: The above Debtors are four of 157 affiliated Debtors in the Federal-Mogul bankruptcy proceedings. While these four Debtors are the only companies affiliated with Federal-Mogul that have been sued in asbestos property damage litigation, you may assert a claim against any one of the 157 affiliated companies. Please consult the Federal-Mogul Claims Website, the Federal-Mogul Claims Helpline, or the Claims Agent listed below to obtain a complete list of the Debtors.

Your Property Damage Claim Must Be Filed by March 3, 2003 at 4:00 P.M.

PLEASE TAKE NOTICE that the United States Bankruptcy Court for the District of Delaware (the "Court") has established March 3, 2003 at 4:00 p.m., Eastern time (the "Bar Date"), as the last date and time by which claims may be filed in the Debtors' chapter 11 cases on account of damage caused by asbestos to property located in the United States and Canada (the "North American PD Claims"). North American PD Claims include claims from losses or damages to property or property interests for which any of the Debtors may be liable arising out of such things as the cost of removal, testing and maintenance, or the diminution in value resulting from any products or material containing asbestos. **All entities, including governmental units, that wish to assert any North American PD Claims against the Debtors are required to file proofs of claim on or before 4:00 p.m., Eastern Time, on March 3, 2003.**

PROCEDURE FOR FILING PROOFS OF CLAIM

If you wish to assert a North American PD Claim, you are required to use the Debtors' proof of claim form for North American PD Claims. **These forms can be downloaded from the Federal-Mogul Claims Website, or obtained by calling the Federal-Mogul Claims Helpline listed below.**

ADDITIONAL INFORMATION

Additional information about the claims process and the Bar Date may be obtained from the Federal-Mogul Claims Website, the Federal-Mogul Claims Helpline, or the Claims Agent listed below. Information about asbestos-containing products manufactured or sold by the Debtors, the known geographic regions where the asbestos-containing products were applied and the dates of such applications, and the names of the Debtors' sub-licensees who may have sold or applied the asbestos-containing products may also be obtained from the website.

CONSEQUENCES OF FAILURE TO FILE PROOF OF CLAIM

Any entity that fails to file a proof of claim by March 3, 2003, shall be forever barred, estopped, and enjoined from asserting any North American PD Claim against the Debtors; or voting upon, or receiving any distributions under any plan or plans of reorganization in these chapter 11 cases in respect of such claims.

You may wish to consult an attorney regarding this matter.

This is a summary notice only.

For complete information, including all relevant forms, notices and instructions, please consult:

Federal-Mogul
Claims Website
www.fmoclaims.com

Federal-Mogul
Claims Helpline
1-888-212-5571

Claims Agent for Federal-Mogul
The Garden City Group, Inc.
P.O. Box 8872
Melville, NY 11747-8872

the bodies and pillage the graves of people who have been dead more than 500 years. I'm sure that the recent descendants of soldiers killed in the U.S. Civil War would be horrified to think that the bones of their dead would be exhumed in a few hundred years to determine the color of their uniforms.

JOHN LAMB
Ladysmith, British Columbia

When I went back to my home country of Peru in 1990 on a tour, I remember being asked if I wanted to take a mummy with me back to Europe. I was quite surprised to hear such an offer. I told my guide that I would like to see the mummies, but I would not take one with me. We drove from Nasca and arrived at a sandy area where we saw at least 10 to 12 deteriorating mummies lying on the sand. The whole area was covered with white bones and pieces of mummies. My guide told me that the *huaqueros* [looters] dig in these areas, and if they find a mummy without nice textiles, they just leave it out there. I was offered textiles, and I was even tempted to buy one, but I didn't want to promote the destruction of our history.

MIGUEL CORTÉS
Vaduz, Liechtenstein

Catfish Hunters

Your article brought back memories of growing up in Georgetown, Guyana, in the sixties as the son of missionaries. I remember fishing in trenches along the roads the same way described in your article. We would put a short length of hollow pipe under the water in a trench alongside the road and leave it. We would come back the next day, feel for the pipe under the water, cover both ends with our hands, and throw the pipe onto the road behind us. Nine times out of ten we would end up with at least one fish flopping on the road, sometimes four or five. Thinking back, I also remember the snakes that would pop their heads out of those trenches, hiss, and show their fangs. I'm not sure that as an adult I'd be sticking my hands in those trenches today.

JOHN MURPHY
Belleville, Ontario

GEOGR

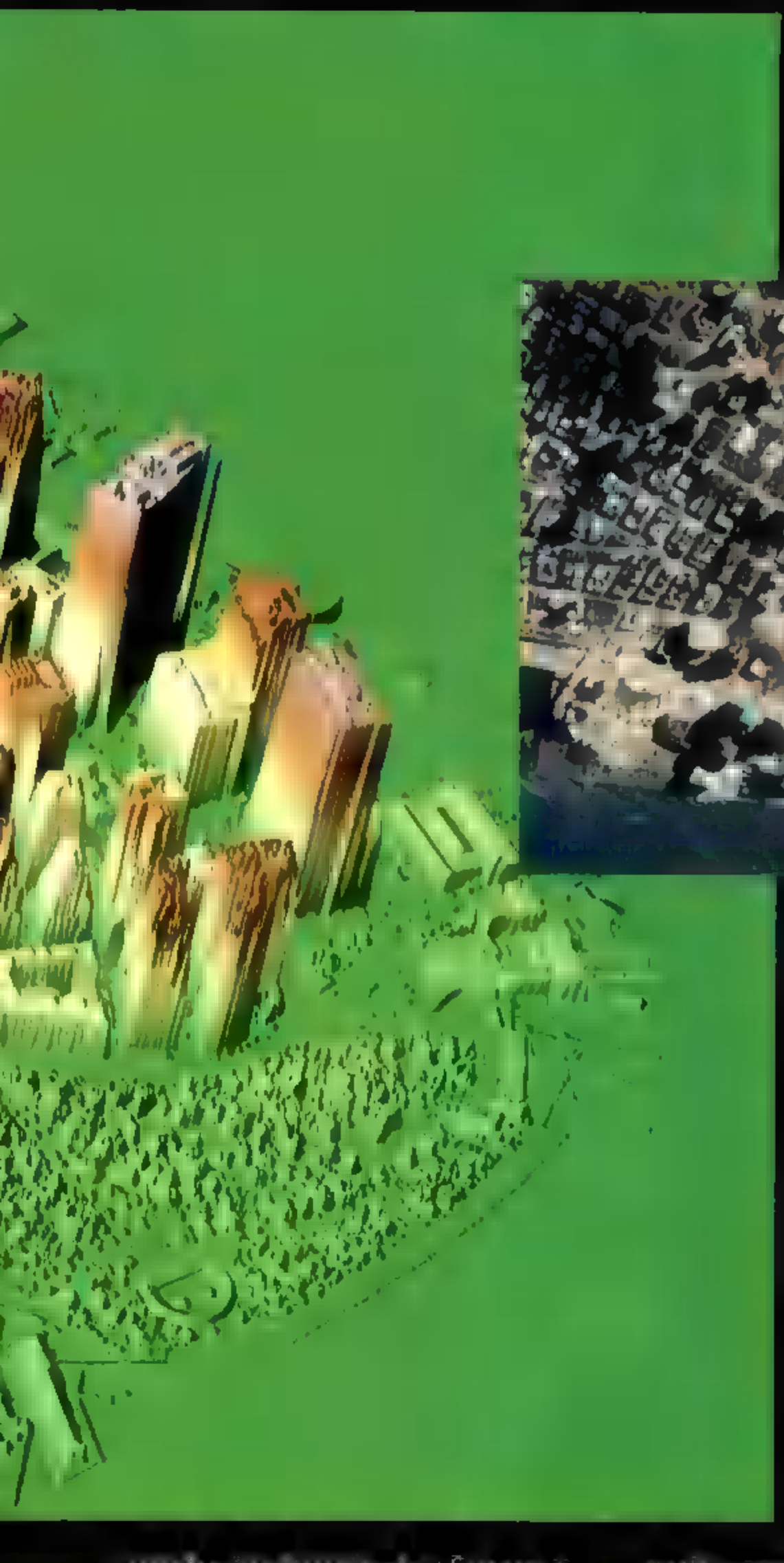
THE PEOPLE, PLACES, AND

You don't often associate [illegible] "feminism" and "cartography." But just hours after the collapse of the World Trade Center buildings last September 11, cartographic experts across New York City were working fast to put the dimensions of the disaster down on paper, helping rescuers and recovery workers navigate at the site. They too [illegible]

"No one could have imagined the magnitude of this event," says Chris Schielein of Environmental Systems Research Institute (ESRI), a company that specializes in geographic information system (GIS) software, which allows layers of data to be displayed as maps. By September 14, banks of computers running GIS programs were already humming at ESRI's 92,

an empty terminal on the Hudson River set up as an emergency mapping center.

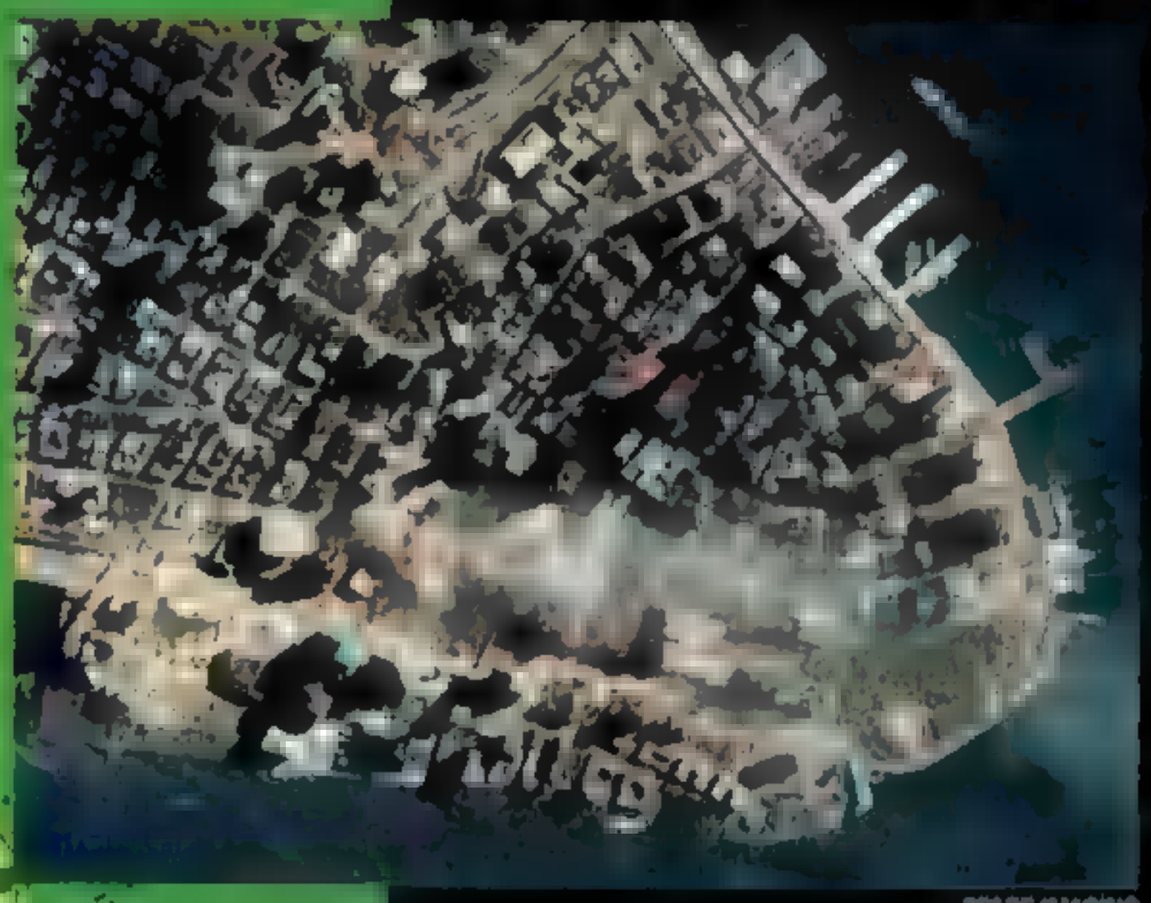
From there and from other sites across the city, specialists from city agencies, private firms such as ESRI, and the federal government combined as a team to meld maps of Manhattan with [illegible] data on the damage. Under [illegible] their around-the-clock efforts were



CARTOGRAPHY

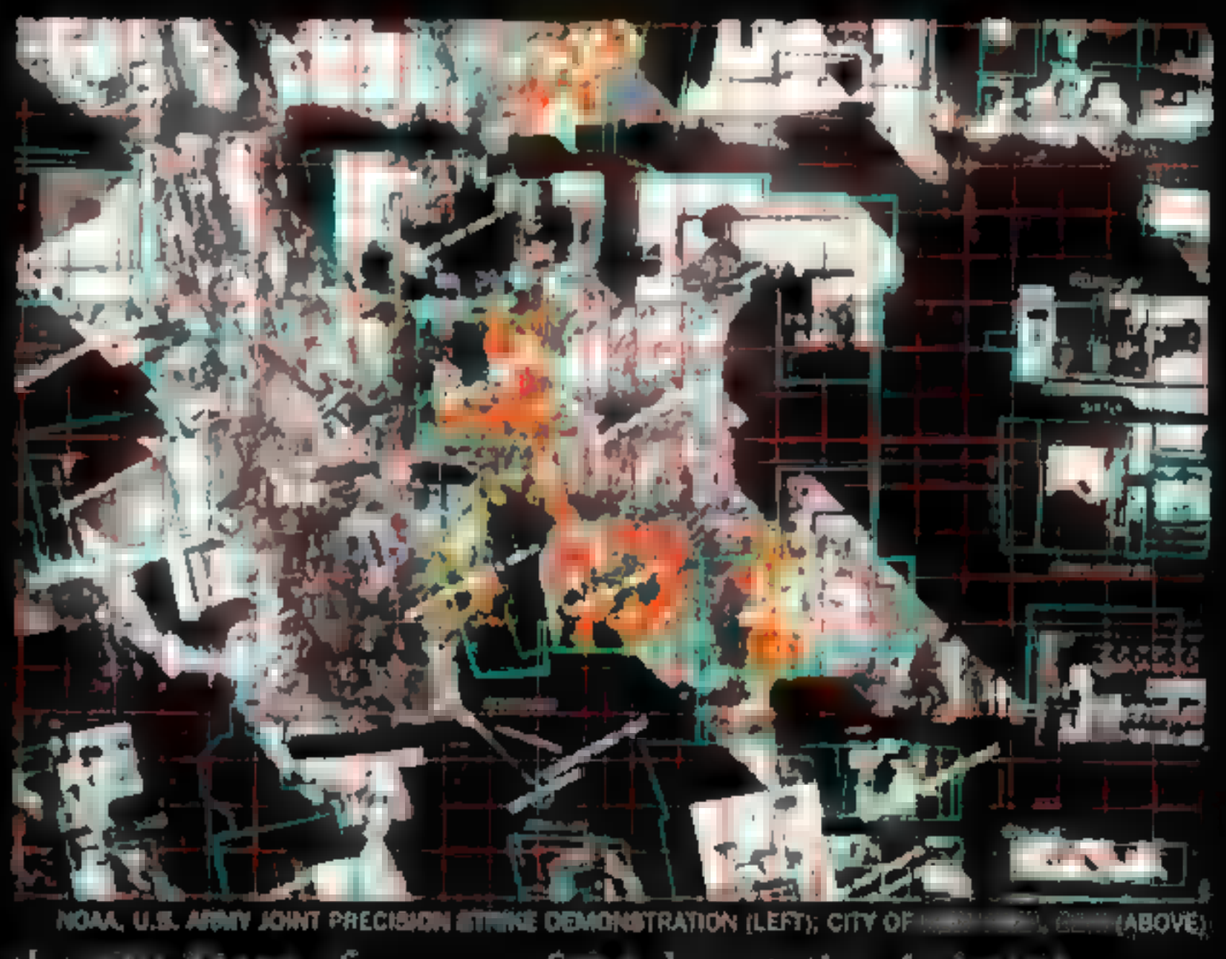
Mapping Disaster

Cartographers aid workers at ground zero



SPACE IMAGING

Government planes used LIDAR—a kind of 3-D laser radar—to gauge rubble height at ground zero. A satellite view (inset, left) showed the smoke plume's drift on September 15. Thermal scans of underground fires (below, in orange) layered upon green building outlines helped rescuers avoid danger.



NOAA, U.S. ARMY JOINT PRECISION STRIKE DEMONSTRATION (LEFT); CITY OF [redacted] (ABOVE)

produced hundreds of maps a day by the end of Fire 92's first week in operation.

The maps they made provided information on everything from the structural integrity of the World Trade Center's overall to places where rescue workers could get cold drinks. They charted the density of the acrid smoke plume and used computer models to track its daily path across the city. Maps of street closings, gas and electric outages, and loss of water and telephone service were updated daily, sometimes every few hours—and distributed to anyone who needed them.

Other mapping technologies also played a vital role. Since air traffic was limited after the disaster, satellite photographs offered immediate aerial views of the devastation in lower Manhattan (inset). Several days later, airplane-mounted laser observation scanning (LIDAR) devices—think speed guns—used their lasers to pierce clouds of smoke and dust and thus locate hidden support structures in wrecked buildings. Additional LIDAR views (above, left) showed color-coded heights of the damaged structures and the

constantly shifting rubble pile. This information helped officials know how tall cellular-mounted cranes needed to be. A third technology, thermal scans, helped firefighters pinpoint underground fires burning near fuel and [illegible] tanks (preceding page, lower right).

From before September 11, New York City had in place an extensive digital base map so detailed it shows home plate at Yankee Stadium. Known as NYCMAP (pronounced nick-map), it was compiled from some 5,000 aerial photographs. In the disaster's aftermath, NYCMAP served as a geographic foundation for information critical to Manhattan residents, including damaged buildings, assessments (above) and access to transportation and other public services.

Other cities—Philadelphia, Seattle, and San Diego, to name a few—have similar mapping [illegible] says Alan Leidner, the director of GIS for New York City's Department of Information Technology. "Because we were working with an accurate geography of the city, we were able to get up and running very quickly."

Dave Kehrlein, California state geographic information expert, was one of many geographers from across the country who traveled to New York last September to help the mapping effort. He hopes that GIS technology gets more national attention and more government funding.

"Preparation for a terrorist attack is no different than preparation for an earthquake or a flood," he says. "We have natural disasters often enough in California that we take GIS very seriously. If another attack happens, we know we're going to be asked to get [illegible]."

MORE ON OUR WEBSITE

Find links and [illegible] by our Research Division at nationalgeographic.com/ngm/resources/0209.

NGS RESEARCH GRANT

Small Clue to a Big Mystery

Did Triceratops' wide collar help it chew food?

Everybody knows *Triceratops.* Like most horned dinosaurs, or ceratopsians, *Triceratops* had a rhino-like body, a beak, and a collared head. Yet scientists have never been sure of the purpose of the ceratopsian collar, or frill. Was it meant to be scary to predators? Or sexy to another ceratopsian? Did it protect the animal's neck from attacking predators? Or serve as a kind of heat radiator, helping ceratopsians cool off? Now the discovery of an even older ceratopsian—smaller than *Triceratops'* skull (silhouette)—has given them a clue: The frill may have helped ceratopsians eat.

Liaoceratops yanzigouensis (below) was discovered in northeastern China by paleontologist Xu Xing, a National Geographic Society grantee. Xu's beagle-size dino, which lived some 130 million years ago, had markings on its rudimentary frill bone—not evident in the more elaborate headgear of *Triceratops*—that show that powerful jaw muscles were once attached there. According to paleontologist Peter Makovicky of the Field Museum in Chicago, these muscles must have helped *Liaoceratops* slice off and eat the fibrous plants that made up its vegetarian diet. "This discovery gives us a window on the evolution of all the horned dinosaurs," he says.

ART BY PORTIA SLOAN

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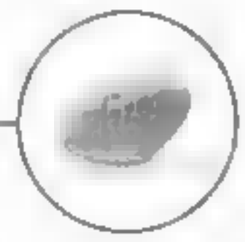
Please see patient summary of information for VIAGRA (25-mg, 50-mg, 100-mg) tablets *on the following page*

VIAGRA is indicated for the treatment of erectile dysfunction. Remember that no medicine is for everyone. If you use nitrate drugs, often used to control chest pain (also known as angina), don't take VIAGRA. This combination could cause your blood pressure to drop to an unsafe or life-threatening level. Discuss your general health status with your doctor to ensure that you are healthy enough to engage in sexual activity. If you experience chest pain, nausea, or any other discomforts during sex or an erection that lasts longer than 4 hours, seek immediate medical help. The most common side effects of VIAGRA are headache, facial flushing, and upset stomach. Less commonly, bluish vision, blurred vision, or sensitivity to light may briefly occur.



PATIENT [redacted] ABOUT

VIAGRA
(sildenafil citrate) tablets

This summary contains important information about VIAGRA. It is not meant to take the place of your doctor's instructions. Read this information carefully before you start taking VIAGRA. Ask your doctor or pharmacist if you do not understand any of this information or if you want to know more about VIAGRA.

This medicine can help many men when it is used as prescribed by their doctors. However, VIAGRA is not for everyone. It is intended for use only by men who have a condition called erectile dysfunction. **VIAGRA must never be used by men who are taking medicines that contain nitrates of any kind, at any time. This includes nitroglycerin. If you take VIAGRA with any nitrate medicine your blood pressure could suddenly drop to an unsafe or life threatening level.**

What is VIAGRA?

VIAGRA is a pill used to treat erectile dysfunction (impotence) in men. It can help many men who have erectile dysfunction get and keep an erection when they become sexually excited (stimulated).

You will not get an erection just by taking this medicine. VIAGRA helps a man with erectile dysfunction get an erection only when he is sexually excited.

How Sex Affects the Body

When a man is sexually excited, the penis rapidly fills with more blood than usual. The penis then expands and hardens. This is called an erection. After the man is done having sex, this extra blood flows out of the penis back into the body. The erection goes away. If an erection lasts for a long time (more than 6 hours), it can permanently damage your penis. You should call a doctor immediately if you ever have a prolonged erection that lasts more than 4 hours.

Some conditions and medicines interfere with this natural erection process. The penis cannot fill with enough blood. The man cannot have an erection. This is called erectile dysfunction if it becomes a frequent problem.

During sex, your heart works harder. Therefore sexual activity may not be advisable for people who have heart problems. Before you start any treatment for erectile dysfunction, ask your doctor if your heart is healthy enough to handle the extra strain of having sex. If you have chest pains, dizziness or nausea during sex, stop having sex and immediately tell your doctor you have had this problem.

How VIAGRA Works

VIAGRA enables many men with erectile dysfunction to respond to sexual stimulation. When a man is sexually excited, VIAGRA helps the penis fill with enough blood to cause an erection. After sex is over, the erection goes away.

VIAGRA Is Not for Everyone

As noted above (*How Sex Affects the Body*), ask your doctor if your heart is healthy enough for sexual activity.

If you take any medicines that contain nitrates—either regularly or as needed—you should never take VIAGRA. If you take VIAGRA with any nitrate medicine or recreational drug containing nitrates, your blood pressure could suddenly drop to an unsafe level. You could get dizzy, faint, or even have a heart attack or stroke. Nitrates are found in many prescription medicines that are used to treat angina (chest pain due to heart disease) such as:

- nitroglycerin (sprays, ointments, skin patches or pastes, and tablets that are swallowed or dissolved in the mouth)
- isosorbide mononitrate and isosorbide dinitrate (tablets that are swallowed, chewed, or dissolved in the mouth)

Nitrates are also found in recreational drugs such as amyl nitrate or nitrite ("poppers"). If you are not sure if any of your medicines contain nitrates, or if you do not understand what nitrates are, ask your doctor or pharmacist.

VIAGRA is only for patients with erectile dysfunction. VIAGRA is not for newborns, children, or women. Do not let anyone else take your VIAGRA. VIAGRA must be used only under a doctor's supervision.

What VIAGRA Does Not Do

- VIAGRA does not cure erectile dysfunction. It is a treatment for erectile dysfunction.
- VIAGRA does not protect you or your partner from getting sexually transmitted diseases, including HIV—the virus that causes AIDS.
- VIAGRA is not a hormone or an aphrodisiac.

[redacted] To Tell Your Doctor [redacted] You Begin [redacted]

Only your doctor can decide if VIAGRA is right for you. VIAGRA can cause mild, temporary lowering of your blood pressure. You will need to have a thorough medical exam to diagnose your erectile dysfunction and to find out if you can safely take VIAGRA alone or with your other medicines. Your doctor should determine if your heart is healthy enough to handle the extra strain of having sex.

Be sure to tell your doctor if you:

- have ever had any heart problems (e.g., angina, chest pain, heart failure, irregular heart beats, or heart attack)
- have ever had a stroke
- have low or high blood pressure
- have a rare inherited eye disease called retinitis pigmentosa
- have ever had any kidney problems
- have ever had any liver problems
- have ever had any blood problems, including sickle cell anemia or leukemia
- are allergic to sildenafil or any of the other ingredients of VIAGRA tablets
- have a deformed penis, Peyronie's disease, or ever had an erection that lasted more than 4 hours
- have stomach ulcers or any types of bleeding problems
- are taking any other medicines

VIAGRA and Other Medicines

Some medicines can change the way VIAGRA works. Tell your doctor about **any medicines** you are taking. Do not start or stop taking any medicines before checking with your doctor or pharmacist. This includes prescription and nonprescription medicines or [redacted]. Remember, VIAGRA should never be used with medicines that contain nitrates (see *VIAGRA Is Not for Everyone*). If you are taking a protease inhibitor, your dose may be adjusted (please see *Finding the Right Dose for You.*) VIAGRA should not be used with any other medical treatments that cause erections. These treatments include pills, medicines that are injected or inserted into the penis, implants or vacuum pumps.

Finding the Right Dose for You

VIAGRA comes in different doses (25 mg, 50 mg and 100 mg). If you do not get the results you expect, talk with your doctor. You and your doctor can determine the dose that works best for you.

- Do not take more VIAGRA than your doctor prescribes.
- If you think you need a larger dose of VIAGRA, check with your doctor.
- VIAGRA should not be taken more than once a day.

If you are older than age 65, or have serious liver or kidney problems, your doctor may start you at the lowest dose (25 mg) of VIAGRA. If you are taking protease inhibitors, such as for the treatment of HIV, your doctor may recommend a 25 mg dose and may limit you to a maximum single dose of 25 mg of VIAGRA in a 48 hour period.

How To Take VIAGRA

Take VIAGRA about one hour before you plan to have sex. Beginning in about 30 minutes and for up to 4 hours, VIAGRA can help you get an erection if you are sexually excited. If you take VIAGRA after a high-fat meal (such as a cheeseburger and french fries), the medicine may take a little longer to start working. VIAGRA can help you get an erection when you are sexually excited. You will not get an erection just by taking the pill.

Possible Side Effects

Like all medicines, VIAGRA can cause some side effects. These effects are usually mild to moderate and usually don't last longer than a few hours. Some of these side effects are more likely to occur with higher doses. The most common side effects of VIAGRA are headache, flushing of the face, and upset stomach. Less common side effects that may occur are temporary changes in color vision (such as trouble telling the difference between blue and green objects or having a blue color tinge to them), eyes being more sensitive to light, or blurred vision.

In rare instances, men have reported an erection that lasts many hours. You should call a doctor immediately if you ever have an erection that lasts more than 4 hours. If not treated right away, permanent damage to your penis could occur (see *How Sex Affects the Body*).

Heart attack, stroke, irregular heart beats, and death have been reported rarely in men taking VIAGRA. Most, but not all, of these men had heart problems before taking this medicine. It is not possible to determine whether these events were directly related to VIAGRA.

VIAGRA may cause other side effects besides those listed on this sheet. If you want more information or develop any side effects or symptoms you are concerned about, call your doctor.

Accidental Overdose

In case of accidental overdose, call your doctor right away.

Storing VIAGRA

Keep VIAGRA out of the reach of children. Keep VIAGRA in its original container. Store at room temperature, 59°-86°F (15°-30°C).

For More Information on VIAGRA

VIAGRA is a prescription medicine used to treat erectile dysfunction. Only your doctor can decide if it is right for you. This sheet is only a summary. If you have any questions or want more information about VIAGRA, talk with your doctor or pharmacist, visit www.viagra.com, or call 1-888-4VIAGRA.

Rev. 4, June 1999

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ARCHAEOLOGY

Bringing Back the Bronze

Greek statue found undersea yields an inner secret

He'd been relaxing off the coast of Croatia on the floor of the Adriatic (above) for almost 2,000 years before a passing scuba diver spotted him in 1997. He was already a few hundred years old and not in the best shape when he came to rest there—lost while being moved from his original home in Greece or present-day Turkey. Now scientists restoring this fourth-century B.C. bronze (right) are getting clues about the figure's history from a most unlikely source: an ancient mouse nest in his hollow right leg. Because of the positioning of the nesting material and nuts, "we know it had been lying on its back for some time before it was lost at sea," says archaeologist Robert Stenuit. Pieces of worked wood suggest the figure had been repaired before its fateful voyage, which took place in the 1st century A.D., according to carbon dating of the nest.

Once hundreds of these life-size athlete statues, called *apoxyomenoi*, stood in public spaces all over Greece. Only a few remain, and most have been found underwater, according to Stenuit. "The rest were probably melted down for the bronze," he says.

The statue's painstaking restoration (left), begun in 1999, will probably be finished next year. But one essential step has already been taken before its eventual display at the National Archaeology Museum in Zagreb: The mouse nest has been removed.

STENUIT (TOP); CROATIAN MINISTRY OF [redacted] (MIDDLE AND ABOVE)

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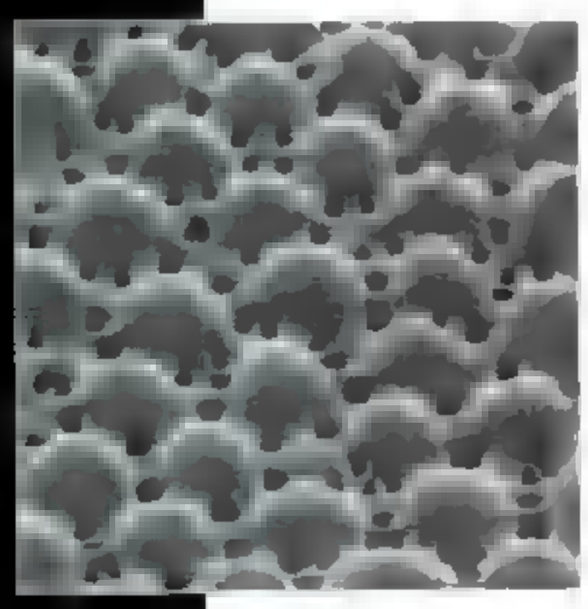
NATURE

A Creature With 50,000 "Eyes"

Brittle star's tiny lenses may spur optical technology



JOANNA AIZENBERG, BELL LABORATORIES, LUCENT TECHNOLOGIES (BOTH)

None of the echinoderms, such as sea stars and brittle stars, appear to have eyes. But marine biologists diving on reefs have noticed that some brittle stars seem to see them coming and flee. They also sport a darker hue during daylight and turn lighter at night.

"So we wondered just what was going on," says Joanna Aizenberg, a materials scientist at Lucent Technologies' Bell Laboratories. She has made an astonishing discovery: At least one brittle star species, *Ophiocoma wendtii*, is covered with 50,000 to 100,000 tiny lenses that gather light like eyes.

"By day it's as if they're wearing sunglasses," she says. "They exude pigment that covers the lenses and blocks light (left, top)." At night, bottom, the brittle star uncovers the lenses, made of calcite crystals. They appear as bumps in the close-up, above. Aizenberg says the lens array may help scientists improve technology such as fiber optics.

CONSERVATION

Last Stand for Ibis?

WERNER STEFFEN

Along the Moroccan coast, a handful of large birds with curved bills cling to the sea cliffs where they breed. Once widespread in Europe, the Middle East, and North Africa, the northern bald ibis has dwindled to about 300 individuals, partly due to habitat loss. In 1991 the Moroccan government created Souss-Massa National Park as a refuge for the ibises, and seven local people have been trained as wardens to protect them. But some of the parkland was reserved for tourism development—land that is critical to the ibises' survival, according to BirdLife International. The group is working with Club Med to ensure that a planned resort will also accommodate the ibises.

Behind the SCENES

AT THE NATIONAL GEOGRAPHIC SOCIETY

A Rest Well Deserved

NATIONAL GEOGRAPHIC reaches the front line

Marine Sgt. Jon Crandall of Parish, New York, takes a break from guard duty in Kandahar, Afghanistan, to read a reporter's perspective of the turmoil there in the December 2001 issue. Before his posting in Kandahar the 22-year-old trooper spent 24 days atop the U.S. Embassy in Kabul as part of a sniper team that helped reopen the building. "We slept on the roof, ate on the roof," he says. "I expected to see a lot more trouble, but the people in Kabul were starting normal lives again."

TED BANKS

BIRGIT BUHLEIER (ABOVE); PETER McBRIDE

Eureka: Crittercam

In his more serious moments, Greg Marshall (below) calls the device he recently patented an "animal-borne imaging system." But most of the time he uses its nickname: Crittercam. Greg, a producer and director in the Society's TV and film division (who also happens to be a marine biologist), devised ways to gently attach cameras and data recorders to animals like this emperor penguin (left). The results: invaluable scientific data and loads of great pictures.

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FRANKIE CHAMBERLAIN

Long on Impact, Short on Glory

African conservation award honors an unsung pair

Annette Lanjouw (above), director of the International Gorilla Conservation Program, has studied African apes (and advocated for their protection) since 1985. Yet few outside the scientific community know about her. That makes her a perfect choice for the new National Geographic Society/Howard Buffett Award for Leadership in African Conservation. She shares the first annual award with Lorivi Ole Moirana, chief warden of Tanzania's Kilimanjaro National Park. "We were looking for people who've made a difference but don't get the recognition they deserve," says John Francis, executive director of the Society's new Conservation Trust. The trust worked with Buffett, an agribusinessman and conservationist, to choose the winners, each of whom receives $25,000.

© THE [illegible] NATIONAL MUSEUM ARCHIVES

Trail's End

We've always wondered who those guys in the Speedaker are in the [illegible] in the October 1923 issue. Note at least one of them can be identified. James [illegible] of Colby-ville, Texas, [illegible] by to tell us that the man wearing his hat in the front seat is his grandfather, Arthur Marcy. It figures: Marcy was the first Studebaker dealer in [illegible], California, and often staged stunts to promote his cars.

Ancient History With a Modern Twist

Third-grade teacher Sherrill Kauffman of Richmond, Virginia, won a local award for excellence in part because of what she proposed to do with her prize money. "It had to be an experience that would change your teaching," she explains. She chose an NG Expeditions tour of the Mediterranean, making digital videos with puppets to teach her students about places like Rome, Pompeii, and the Greek island of Rhodes (right). When she returned from the trip she created a website for her students. "They couldn't believe it was really me," she says.

SANDRA OSGOOD MONTEVALDO

FOR MORE INFORMATION

Call: 1-800-NGS-LINE
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On the edge of ground zero stands St. Paul's Chapel, miraculously untouched and ready to serve. After the towers fell, the tiny 18th-century Episcopal church became a refuge for rescue workers: Ministers counseled, cooks dished out meals, and medical volunteers treated stiff muscles and burned feet. Hear firsthand stories and view a 360-degree photo of the chapel covered with the public's good wishes at *nationalgeographic.com/ngm/0209*.

STEVE McCURRY

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Photographed by Tom and Pat Leeson

WILDLIFE AS CANON SEES IT

A sea otter mother and pup stay together constantly for six months or more. During diving forages, however, the pup waits alone at the surface, buoyed by a layer of air trapped in the fibers of its water-resistant fur. Sea otters have the densest fur of any mammal, and daily grooming maintains their only insulation against cold. Recently, sea otter populations in western Alaska plummeted as they unexpectedly became altered prey for killer whales following sharp declines in the whales' main food source of seals and sea lions. Otters play a key role in marine ecosystems, and the ultimate impact of their disappearance is yet to be fully realized.

As a global corporation committed to social and environmental concerns, we join in worldwide efforts to promote greater awareness of endangered species for the benefit of future generations.

Sea Otter *(Enhydra lutris kenyoni)*
Size: 120-140 cm
Weight: 20-40 kg
Habitat: Shallow coastal waters off Alaska, from Prince William Sound, north to Bristol Bay and extending west to the Aleutian Islands
Surviving number: Estimated at 8,500 in the Aleutian Islands, where a 90 percent decline has occurred since 1990

NATURE

Canon

National Geographic TV

JAMES KEGLEY, NGCI

Inside Pharaoh Khufu's Great Pyramid exists a mysterious stone, blocking a shaft for more than 4,000 years. What lies behind it? The pharaoh's tomb? On September 16, share the moment of discovery on live TV when Zahi Hawass, a National Geographic explorer-in-residence (above), deploys a remote-controlled robot to look inside the secret space.

MARK THIESSEN, NGS

NATIONAL GEOGRAPHIC EXPLORER, MSNBC

Boyd Rocks

Game for anything, from scaling ice cliffs to hiking deserts, host Boyd Matson sights new adventure as EXPLORER begins year two on MSNBC.

NATIONAL GEOGRAPHIC SPECIAL, PBS

Ambassador

Their duties demand grace and resolve. How do you present yourself as an ambassador? How do you persuade a reluctant ally to fight terrorism? It's a tough job, sometimes a cruel one. Prudence Bushnell, former U.S. Ambassador to Kenya (right), counsels victims of the Nairobi embassy bombing. *Ambassador* takes an inside look at the very human art of diplomacy.

JOHN MCCONNICO, AP PHOTO

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To help his class understand the role old Route 66 played in the past, Mr. Walk's students created murals, brochures and interviewed residents, which helped them experience a part of local history. State Farm is proud to present Fred Walk with the Good Neighbor Teacher Award and also donate $10,000 to Normal Community High School in Normal, Illinois.

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Who Knew?

ALLERGIES

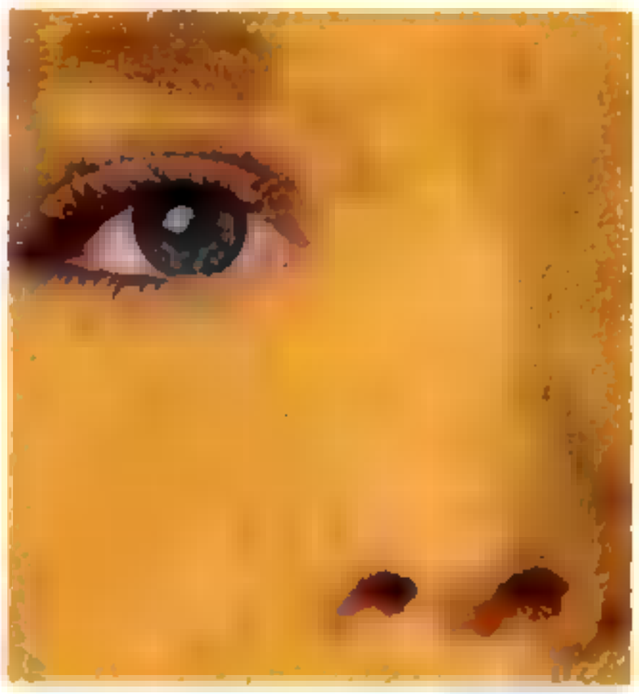
Down and Dirty

Did having a nice, clean childhood give you hay fever?

Allergies are becoming so common you'd think they were contagious. They're almost fashionable. I know people who attribute every sniffle or mood swing to an allergy, in the same way that every heat wave, fogbank, or thunderclap gets blamed on global warming.

You may have noticed that Lewis and Clark didn't complain that the great outdoors gave them hay fever. That's because the ailment was so rare it hadn't yet been described in medical literature. Only in 1819 did a doctor describe an illness in which the eyes get itchy and the nose runny.

Respiratory allergies and asthma (a closely related disease) seem to have been on the rise ever since. Some scientists have offered an intriguing, if unproved, explanation: the hygiene hypothesis. Basically, our lives aren't dirty enough.



CARY

To fight invaders, our immune system uses a battalion of cells, notably two commandos called Th1 and Th2. An allergy or asthma sufferer's Th2 cells are out of control, waging total war against harmless substances. When such a person's Th2 cells encounter one of the millions of pollen grains churned out by the average ragweed plant, they trigger the production of immunoglobulin E—a weapon designed to fight disease, not pollen—inflaming the respiratory passages in the process.

What made the human immune response misfire after a few million years of working just fine? Our modern, man-made environment may hold the answer.

"What's the major health change of the past 200 years? It's basically hygiene," says Calman Prussin, a researcher with the National Institute of Allergy and Infectious Diseases. For many people the days of unsanitary, crowded environments—and the bacteria, viruses, and parasites that come with them—have passed.

This could explain some provocative findings. Respiratory allergies seem to be less prevalent in poor societies than in rich ones. People raised on farms have lower rates of allergies than those raised in cities. Children who attended day care have lower allergy rates.

What's going on at the cellular level? No one's sure, but the key may be the balance of power between our Th1 and Th2 defenses. Perhaps our immune systems need to be calibrated in childhood, "learning" to produce Th1 when assaulted by diseases like hepatitis A and tuberculosis. Now that these illnesses are scarcer, at least in some parts of the world, many of us may not produce enough Th1 to help control that rampaging Th2.

So maybe we're cave people trapped in a world of antibacterial hand wash. Still, compared with the diseases our ancestors suffered, notes Prussin, "it may not be so bad to have an itchy nose."

—Joel Achenbach
WASHINGTON POST STAFF WRITER

IT MATTERS

Every bad reaction—to a plant, a pet, or a pill—isn't an allergy. Consider penicillin. Ten out of every hundred patients in U.S. hospitals report that they're "allergic" to penicillin, but at least six of those are almost certainly wrong. Side effects common to antibiotics—like diarrhea and stomachache—don't mean you're allergic. Genuine penicillin allergy is an immune system blowup: Reactions vary from merely miserable (hives) to life threatening (constricted airways and tumbling blood pressure). It matters that you know if you're truly allergic because penicillin remains the first-choice treatment for infections from strep throat to syphilis. Rule it out and you may have to settle for a less effective, more expensive drug with a longer list of potentially nasty side effects.

—Lynne Warren

MORE ON OUR WEBSITE

Welcome to Who Knew?—a new science column by Joel Achenbach. This month there's more on allergies at **nationalgeographic.com/ngm/resources/0209.**

CHALLENGES FOR HUMANITY

The Earth's six billion people already overtax its supply of accessible fresh water. What happens when the planet gets a few billion more hands?

By Fen Montaigne
Photographs by Peter Essick

Water Pressure

Drawing deep from a new well, Sali Sotiar is among a lucky few: the 10 to 20 percent of rural Ethiopians with access to clean drinking water.

Oil and Water

SOME FLOWS THEY MIX — FINE

In bone-dry Dubai 2.6 million gallons of expensively desalinated seawater flows through Wild Wadi Water Park's pools and water coasters, proving that water's no problem when money's no object. Flush in oil and cash, Persian Gulf governments can afford to do what most water-poor nations can't even imagine: desalinate sea water for almost all their freshwater needs.

Pipe Dreams

WHERE WATER IS OUT OF REACH

On the outskirts of Delhi, India, squatters live in the shadow of a pipe carrying water to the city. As in many cities in the developing world, Delhi's population is growing so fast its water supply can't keep up; only half the city's inhabitants can get treated water in their homes. These squatters have indirect access—they drink water in the pipe's leaks.


DINESH
CYCLE

All over the globe farmers and municipalities are pumping

Rajendra Singh came to the village, bringing with him the promise of water.

If ever a place needed moisture, this hamlet in the desiccated Indian state of Rajasthan was it. Always a dry spot, Rajasthan had suffered several years of drought, leaving remote villages like Goratalai with barely enough water to quench the thirst of their inhabitants. Farm plots had shriveled, and men had fled to the cities seeking work, leaving those behind to subsist on roti, corn, and chili paste. Desperate villagers appealed to a local aristocratic family, who in turn contacted Singh, a man renowned across western India for his ability to use traditional methods of capturing monsoon rains to supply water year-round.

Singh arrived in Goratalai on a warm February morning. The sky was robin's egg blue, the same color it had been since August when, everyone recalled, the last rains had fallen. He was greeted by a group of about 50 people waiting in a dirt square under a banyan tree. The men wore loose-fitting cotton pantaloons and turbans of orange, maroon, and white. They were rail-thin, their faces burnished by the sun and distinguished by great mustaches that swept across hollow cheeks. The women were covered from head to toe in vivid orange, gold, and pink clothing, a counterpoint to the parched dun terrain of rock and scrub.

Singh smiled and addressed the villagers.

"How many households do you have?"

"Eighty."

"It's been four years without much rain," interjected a woman. "And we don't have a proper dam to catch the water."

"Do you have any spots where a dam could go?" asked Singh, 43, who has a full head of black hair and a thick beard, both flecked with gray.

"Yes, two spots."

"Will the whole village be willing to work there?"

"Yes," they replied in chorus. The villagers, nearly all of them illiterate, had submitted a petition to Singh asking for help, their names represented by violet thumbprints on a smudged piece of paper.

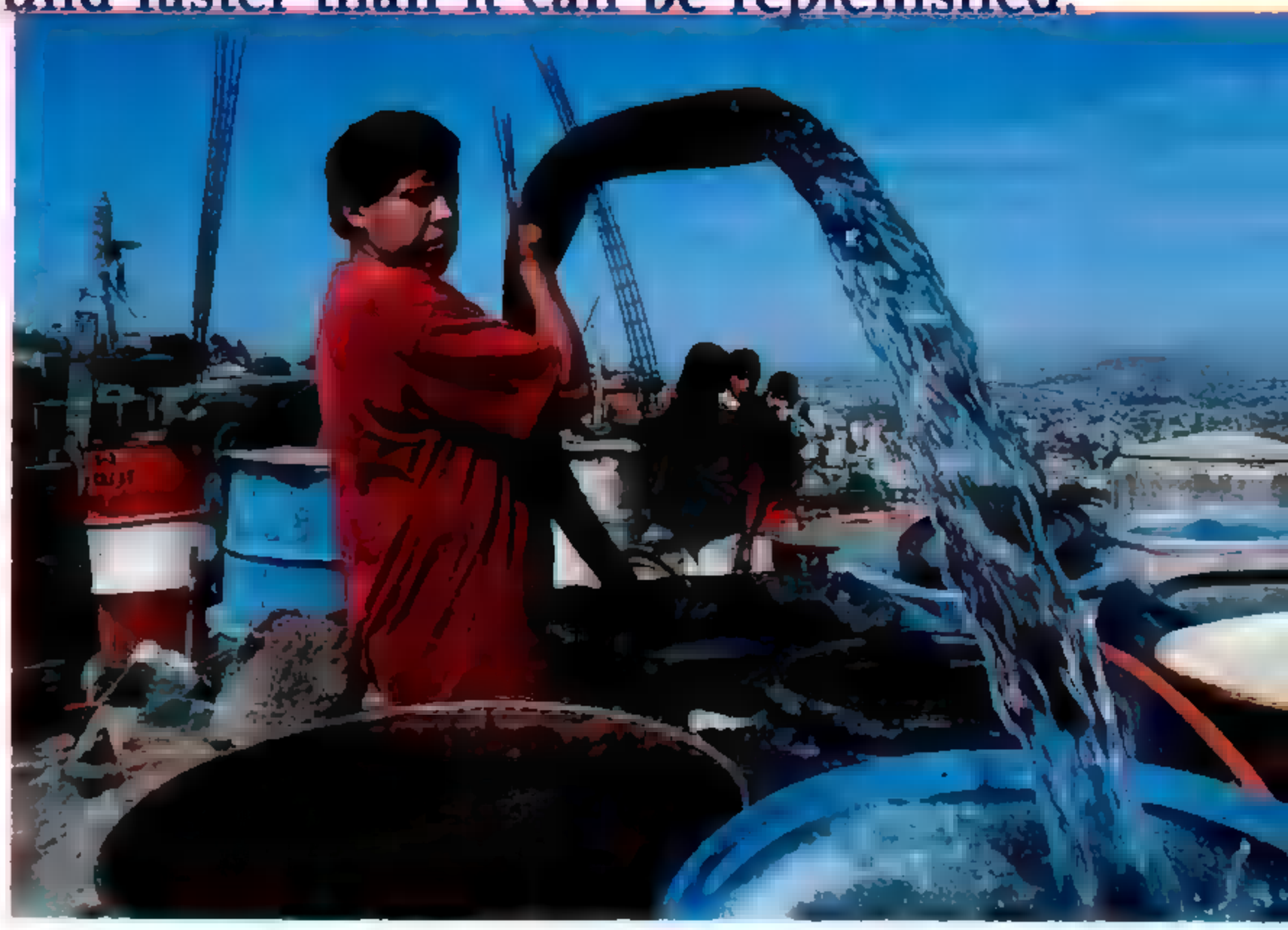
"I would like to help you," Singh told them, "but the work has to be done by you. You will have to provide one-third of the project through your labor, and the remaining two-thirds I will arrange."

The villagers clapped, the women broke into song, and the group hiked across the rock-studded hills to a ravine, the women's silver ankle bracelets jangling as they walked. After a few minutes Singh—dressed in a light-golden blouse that fell to his knees and white pants—directed villagers to place stones in a 75-yard line between two hills. "This is an ideal site," he announced. His organization, Tarun Bharat Sangh, would provide the engineering advice and materials. The villagers would supply the sweat equity. The 30-foot-high earthen dam and reservoir, known as a *johad*, could be finished in three months, before the start of the monsoon. If the rains were plentiful, the reservoir would not only provide surface water for drinking and irrigation but would also recharge dry wells as water seeped into the ground.

"You shouldn't get disheartened," Singh told the villagers. "You will not see the results immediately. But soon the dam will begin to raise the water level in your wells."

Ninety minutes after he arrived, Singh was gone, heading to a nearby village that had also requested help building a johad. In recent years Singh's johads have sprung up all over Rajasthan—an estimated 4,500 dams in about 1,000 villages, all built using local labor and native materials. His movement has caught on, he told me, because it puts control over water in the hands of villagers. "*If they feel a johad* is their own, they will maintain it," said Singh.

water out of the ground faster than it can be replenished.



MEXICO CITY'S LEAKY [illegible]

Population booming as water pipes crumble, Mexico City must truck water to many residents. Once called the Venice of the New World for now long-gone lakes and canals, the city has [illegible] drained its aquifer since 1900 that it has sunk two dozen feet. As ground shifts, pipes break; leaks claim nearly a third of its water.

"This is a very sustainable, self-reliant system. I can say confidently that if we can manage rain in India in traditional ways, there will be sufficient water for our growing population."

AMONG the environmental specters confronting humanity in the 21st century—global warming, the destruction of rain forests, overfishing of the oceans—a shortage of fresh water is at the top of the list, particularly in the developing world. Hardly a month passes without a new study making another alarming prediction, further deepening concern over what a World Bank expert calls the "grim arithmetic of water." Recently the United Nations said that 2.7 billion people would face severe water shortages by 2025 if consumption continues at current rates. Fears about a parched future arise from a projected growth of world population from more than six billion today to an estimated nine billion in 2050. Yet the amount of fresh water on Earth is not increasing. Nearly 97 percent of the planet's water is salt water in seas and oceans. Close to 2 percent of Earth's water is frozen in polar ice sheets and glaciers, and a fraction of one percent is available for drinking, irrigation, and industrial use.

Gloomy water news, however, is not just a thing of the future: Today an estimated 1.2 billion people drink unclean water, and about 2.5 billion lack proper toilets or sewerage systems. More than five million people die each year from water-related diseases such as cholera and dysentery. All over the globe farmers and municipalities are pumping water out of the ground faster than it can be replenished.

Still, as I discovered on a two-month trip to Africa, India, and Spain, a host of individuals, organizations, and businesses are working to solve water's dismal arithmetic. Some are reviving ancient techniques such as rainwater harvesting, and others are using 21st-century technology. But all have two things in common: a desire to obtain maximum efficiency from every drop of water and a belief in using local solutions and free market incentives in their conservation campaigns.

That the planet's fresh water is consumed profligately is beyond doubt, particularly in agriculture, which accounts for 70 percent of all water use. Getting more out of each drop of water is imperative, for as the world's population increases and the demand for food soars, unchecked irrigation poses a serious threat to rivers, wetlands, and lakes. China's Yellow River, siphoned off by farmers and cities, has failed to reach the sea most years during the past decade. In North America not only does the Colorado River barely make it to the Gulf of California, but last year even the Rio Grande dried up before it merged with the Gulf of Mexico. In Central Asia the Aral Sea shrank by half after the Soviets began diverting water for cotton and other crops. Elsewhere, countless small rivers have gone dry.

A fraction of one percent of Earth's water is available for

To see what unbridled water consumption has wrought, both good and bad, you need go no farther than the Indian state of Gujarat. Like neighboring Rajasthan, Gujarat is a dry place that has experienced a surge of irrigated agriculture. In the northern part of the state, on a hot spring day, I came across a brick pump house amid flat green fields of wheat, mustard, cumin, and anise. Inside was the electrical system for a 62-horsepower motor that, ten hours a day, pumped a steady column of water from deep underground into a concrete tank through which the water was channeled to nearby fields. One of the pump's owners—70-year-old Nemchandbhai U. Patel—rested on a rope bed in the cool, dusky interior, lulled by the sound of water rushing up from underground aquifers and gurgling into the tank.

Patel stirred as I approached. He explained that the pump was used to irrigate his fields, as well as those of his partners and 50 other farmers who purchase the water. Without it they would have to rely solely on rain, which in an area that receives about 25 inches of precipitation a year—most of it in short summer cloudbursts—is a highly risky proposition. "Thanks to this well," said Patel, "we are able to sustain our lives."

The electric pump that sent water streaming onto Patel's land is the machine that has powered India's green revolution. That agricultural achievement, which has enabled the country to grow enough food for its one billion people, was accomplished because of a huge increase in groundwater pumping. In the mid-fifties fewer than 100,000 motorized pumps were extracting groundwater for Indian agriculture. Today about 20 million are in operation, with the number growing by half a million each year.

But the unregulated use of so much groundwater has come at a high price: With farmers extracting water more quickly than nature can replenish it, aquifers have been depleted to the point that roughly half of India now faces overpumping problems, such as groundwater shortages or the influx of salt water into coastal wells. Many farmers have been forced to abandon wells or keep drilling deeper, raising costs and driving some out of business. In parts of Gujarat the water table has been dropping as much as 20 feet a year. Four decades ago the water table under Nemchandbhai Patel's fields was at 100 feet; now he must drill 500 feet before he hits water. He keeps deepening his well, but to drill a new one could be prohibitively expensive.

"We think this water may one day be lost to us forever," said Mohanbhai G. Patel, 67, a nearby well owner whose last name is shared by many in the region. "The water we are now pumping from deep underground has been accumulating for thousands of years. It's like this urn here. If you keep drinking water and never refill it, at some point there will be no more. Unless the government brings in major schemes to recharge these aquifers, we will not survive."

One reason farmers in India, and throughout the world, have been heedlessly pumping water is that they have paid so little for it. In India the water itself is free, and the government heavily subsidizes the electricity that drives the pumps. Rather than pay for the number of hours a pump runs, farmers pay a low, flat annual rate and pump with abandon.

The overpumping of aquifers, whether for agricultural or municipal use, extends far beyond India. American farmers are withdrawing water from the Ogallala aquifer, which underlies the Great Plains, at an unsustainable rate, with a third of the Texas portion already significantly depleted. The water table under the North China Plain, which produces about half of China's wheat and corn, is steadily dropping. Sandra Postel, a freshwater expert and director of the Massachusetts-based Global Water Policy Project, said that continuing groundwater depletion could reduce China's and India's grain production by 10 to 20 percent in the coming decades.

Two decades ago, as an idealistic young man intent on helping India's rural poor, Rajendra Singh traveled to northwestern Rajasthan, which was suffering water shortages from excessive groundwater extraction. Shortly after he arrived in the impoverished Alwar district, two things became clear to Singh. The first was that managing water wisely was the key to helping drought-prone villages in the region. The second was that farmers were pumping far too much groundwater.

drinking, irrigation, and industrial use.

"CHINA'S SORROW" ENTERS A SAD NEW SEASON

Named China's Sorrow for its history of ruinous floods, the Yellow River now barely trickles in its lower reaches—and in recent years has gone dry due largely to heavy irrigation upstream. It's not alone: The once mighty Nile, Ganges, and Colorado Rivers barely reach the sea in dry seasons.

"If you replenish water, that is a green revolution," Singh told me. "But if you destroy your water capital, what kind of green revolution is that?"

An old villager showed Singh the numerous earthen dams in the district that had fallen into disrepair, their reservoirs filled with silt. They were remnants of a rainwater collection tradition that dated back 5,000 years in India, a system that used the natural terrain to channel and store the brief monsoon downpours for year-round use. But community rainwater collection schemes fell out of favor during British rule and after independence in 1947; their neglect, coupled with overpumping of groundwater, led to a crisis in villages throughout western India. Singh became consumed with the idea of building johads, gradually helping villagers erect the earthen and stone structures all over Rajasthan.

Today he is perhaps the best known of a large group of people who have revived India's ancient rainwater harvesting techniques, which use not only dams but also underground storage tanks and large concrete-lined reservoirs. Singh's organization—financed by the Ford Foundation, among others—has 45 full-time employees and 230 part-time workers. He spends eight months a year on the road, rarely seeing his wife and son and often sleeping in the backseat of his chauffeur-driven car at night, no small hardship given India's chaotic, treacherous, and polluted highways.

I JOINED SINGH for two days, traveling to a handful of villages where johads had spurred an economic revival. The success of his movement owes much to his personality, which has inspired villagers to follow his lead during the arduous process of building dams, often with their bare hands. His manner is gentle and unflappable, and he spends hours listening to villagers, sometimes sleeping in their huts and eating their food. In the hamlet of Johdi Ki Dhani, where Singh initiated the construction of three johads, the headman said Singh's quiet, persistent ways overcame the residents' initial skepticism.

"Rajendra Singh used to come as a very simple person," said Suraj Mal Gujur, 45. "He would sit among us and not act like a big shot. He eventually established a very close relationship with us."

One of the villages Singh and I visited was Neemi, situated in dry hills about 20 miles from Rajasthan's capital, Jaipur. Neemi's farmers had pumped many of their wells dry, and some were abandoning the land for work in nearby cities. Singh helped them build several large dams, and by the end of the 1990s the reservoirs began recharging depleted groundwater, catalyzing what villagers describe as a remarkable turnaround in Neemi's fortunes.

Today Neemi is a thriving village in a fertile valley, its fields green with wheat, vegetables, watermelons, and flowers. Not only has migration to the cities *(Continued on page 18)*

WATER: How It's Used, How It's Wasted

We tend to think of water in the most personal terms—a mother bathing her child in Calcutta, India (left), or a cool drink on a hot day—but only 10 percent of the water consumed worldwide is for household use. Agriculture takes 70 percent, and half or more of that water is lost to evaporation or runoff. Drip irrigation, which uses perforated tubing to deliver water to crops (above), uses 30 to 70 percent less than traditional methods and increases crop yields to boot. The first drip systems were developed in the 1960s, but even now they're used on less than one percent of irrigated land. Most governments subsidize irrigation water so heavily that farmers have little incentive to invest in drip systems or other water-saving methods. Industry consumes the remaining 20 percent of water, often inefficiently. In Binzhou, China, workers at a liquor company wash bottles with water that is used once and discarded. Reusing water and adopting other conservation measures could help the world's industry cut its water demands by more than half.

Where's the Trouble?

Water statistics can be misleading. They often lump people together on a country-by-country basis, when problems tend to be much more localized than that. In order to look at water stress more precisely, University of New Hampshire researchers developed a map (right) relating population density to water availability. Highly water-stressed populations—where people use more than 40 percent of available renewable water—are indicated by shades of red; less stressed populations are shown in blue. In both cases the deeper the color, the denser the population. Looking through this fine-grained lens, the researchers concluded that nearly two billion people suffer from severe water stress—far more than previously estimated.

But much of this problem seems to disappear when these data are aggregated. In the map below, countries where more than half the population is under high stress are painted gray, making the world's three most populous countries appear just fine. But in fact, China has hundreds of millions of people without enough water, India doesn't fare much better, and the western U.S. has nearly dried up some of its biggest rivers.

Population density and water stress

WATER STRESS

POPULATION DENSITY	Low to medium	High
High		
Medium		
Low		
Extremely low		

SOURCE: CHARLES J. VÖRÖSMARTY AND COLLEAGUES, WATER SYSTEMS ANALYSIS GROUP, UNIVERSITY OF NEW HAMPSHIRE; TIME DATA

NORTH AMERICA
UNITED STATES
CANADA
GREENLAND
Las Vegas
Albuquerque
Great Plains
Mexico City
Matamoros
St. Petersburg
ARCTIC CIRCLE

SOUTH AMERICA
CHILE
Santiago

EUROPE
SPAIN
Delmtl

ASIA
SIBERIA
North China Plain
Binzhou
CHINA
Aral Sea
BANGLADESH
Kolkata (Calcutta)
Tehri
Delhi
Alwar
Jaipur
New Delhi
INDIA
Gorakhpur
Ahmadabad

AFRICA
ETHIOPIA
Amman
JORDAN
Persian Gulf
Dubai
Nile
NAMIBIA
Windhoek
Lusaka
Victoria Falls
Limpopo R.
Ladysmith
Durban
SOUTH AFRICA

TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
Atlantic Ocean
Indian Ocean

Percent of population under water stress by country
75–100
50–74
0–49
LIBYA
SAUDI ARABIA
BOTSWANA

Total population and water stress (population in billions)
Low
Medium
High
1995 (5.87)
2025 (8.0)

A Stressful Future

Between 1995, the last year for which reliable figures are available, and 2025, a billion people are projected to join the ranks of the highly water-stressed. Add 11[illegible] who face a medium level of water stress, and four billion people—most of the planet's [illegible]—will have an insufficient supply of water.

Total freshwater use over time
Cubic kilometers
6,000
4,000
3,000
2,000
1,000
Domestic
Industrial
1700
1800
1950

Thirsty World

Because of irrigated agriculture, the Industrial revolution, and a population explosion, humans use 45 times as much water as they did three centuries ago. Irrigation, which accounts for 70 percent of water use, grows 40 percent of the world's food and makes it possible to feed the planet's 6.2 billion people.

The Dynamics of a Wet Planet

How much water does the planet have? If you smoothed out the Earth—filling the ocean floor with the dry land of the continents—the Earth's entire surface would be covered by 8,800 feet of seawater. Too bad seawater is virtually unusable. If all that water evaporated, the Earth would be covered with more than 40 feet of salt.

The large blue circle inhabiting the map at left represents Earth's salt water, and the smaller circles below represent its fresh water—just 2.5 percent of the total.

OCEANS AND OTHER SALT WATER
Oceans cover 71 percent of the Earth's surface and contain 96.5 percent of its water. Seas or brackish groundwater and saltwater lakes (including large inland seas) make up another one percent.

ICE AND SNOW
Nearly 69 percent of the world's fresh water is frozen in glaciers, permanent snow cover, sea ice, and permafrost. The Antarctic and Greenland ice sheets have the bulk of it.

GROUNDWATER
Thirty percent of all fresh water is groundwater, most of it in deep, hard-to-reach aquifers.

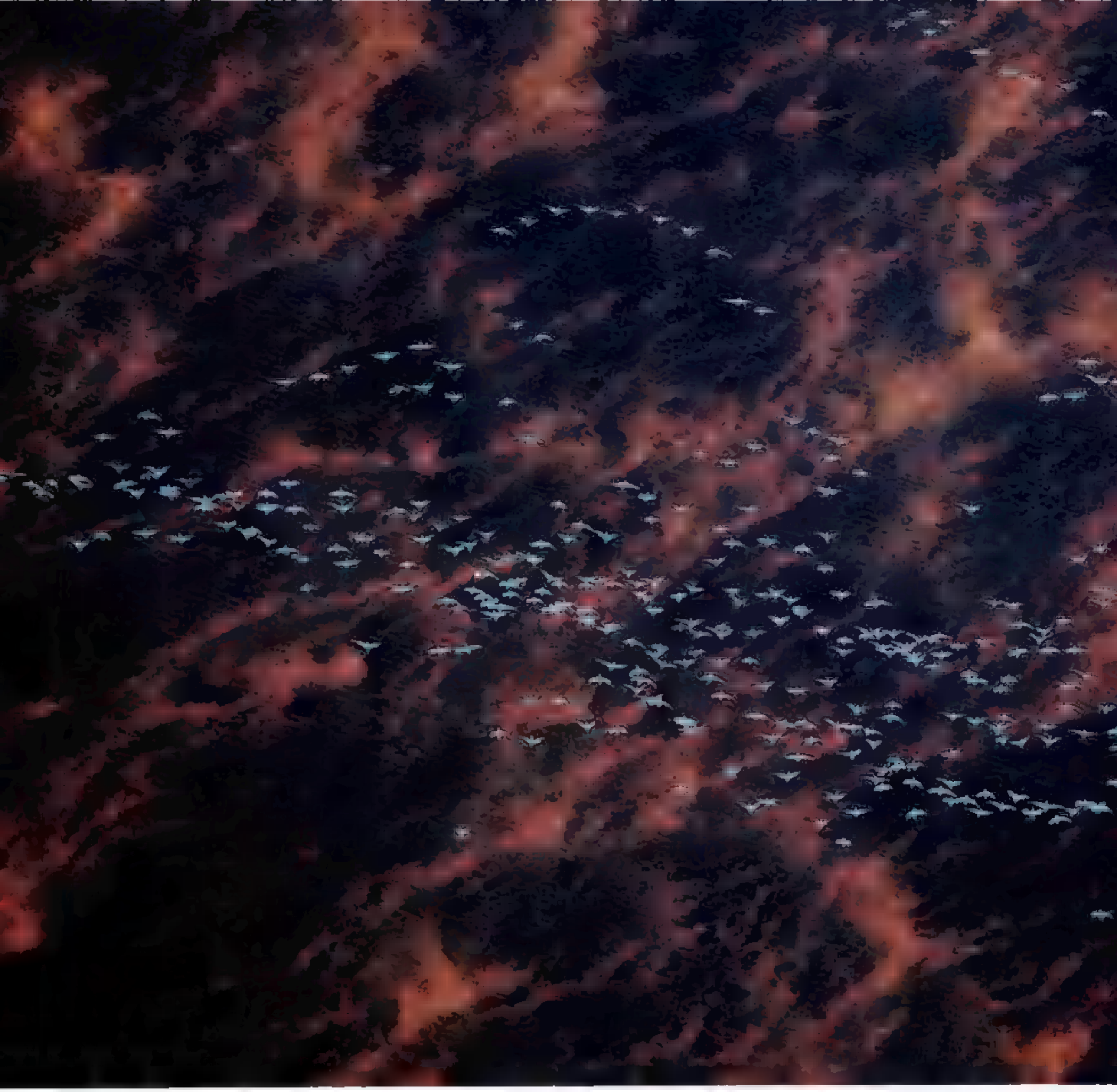
LAKES AND RIVERS
Freshwater lakes and rivers contain just a little more than one-fourth of one percent of all fresh water. Lakes have most of it.

SOILS, WETLANDS, AND MOISTURE
All the dirt, mud, swamps, plants, and animals of the Earth contain just under one-tenth of one percent of fresh water.

ATMOSPHERIC WATER VAPOR
Though clouds and water vapor hold just four one-hundredths of one percent of all fresh water, they still have six times more water than all the world's rivers.

Water on Land

Just because the water's there doesn't mean people can use it. Underground aquifers have a hundred times more water than lakes do, but most of that water is too deep to reach. Freshwater aquifers are being quickly overdrawn in many parts of the world, and much of Earth's groundwater rushes to the sea in floods or ends up in places far from the people who need it. Canada, for instance, has a fifth of the world's surface fresh water but less than one percent of the population.



(Continued from page 11) stopped, but more than 400 farmworkers have also poured into Neemi to cultivate its fruit and vegetables. With more water and fodder available, the number of cattle among Neemi's 122 dairy farmers has increased sharply, quadrupling the village's milk production.

"We knew johads could have an impact," said Radhu Patel, an elderly farmer who was one of Singh's earliest supporters. "But when you're in a car and there's no driver, you can't move the vehicle. Mr. Singh was our driver. Because of his presence we have accomplished all the development you see here."

Singh attributes the growing success of his movement to a basic fact: It encourages local people to build smaller dams and reservoirs in their own backyards, rather than relying on large government-built dams, which often displace residents and transfer water far away.

"This work fulfills the need of the self-reliance of local people," said Singh. "In a small project everyone can participate in decision-making. That's the only real way to improve a community. The community gets employment and has a feeling of ownership and control."

Sunita Narain, director of the nonprofit Center for Science and Environment in New Delhi, said rainwater harvesting is not a panacea and needs to be coupled with conservation measures and, on occasion, the big public works projects Singh abhors. Still, the work of Singh and others has had a profound impact in

India, she said, and is proof of an axiom in the developing world: "Managing water well," said Narain, "is the first step in alleviating poverty."

THE KATUBA REGION, north of the Zambian capital of Lusaka, is not chronically short of water. But it is awash in poverty, and the trick—as Paul Polak knows well—is getting the water from where it lies to farmers' fields, a straightforward task that can bring cash trickling into rural villages.

Polak, a 68-year-old Coloradan fond of wearing orange tennis shoes and suspenders, has spent much of his adult life figuring out how to get water cheaply from point A to point B in the developing world. His own path has not been quite so direct. He was a psychiatrist, who in his extensive travels grew increasingly interested in reducing poverty. Gradually it became clear to Polak that to improve the lives of hundreds of millions of subsistence farmers, water was the starting point.

"You could see how essential water was to alleviating poverty," said Polak. "If you wanted to do anything, you had to start with these small farmers and irrigation. The power to control water is absolutely crucial to them. That fact should shape all development policy."

Polak's shrewd investments in oil and real estate allowed him to spend more time working on improving water delivery to the poor. In 1981 he formed the nonprofit International Development Enterprises (IDE), which has

Collision Course

Migratory birds still flock to California's Tule Lake, but the lake is little more than ■ 10,000-acre, yardstick-deep puddle compared with a century ago, when it reached ten times that size. Most of the water has been diverted for agriculture. In a trend echoed worldwide, 90 percent of California's wetlands have disappeared, and 39 of 67 native fish species are extinct or at risk of extinction. On the nearby Klamath River in Oregon, federal efforts to save three fish species led to ■ confrontation with farmers last year when officials shut off irrigation water during a drought. The flow has been restored—for now.

played a major role in disseminating treadle pumps in several countries, such as Bangladesh, which has 1.3 million. This StairMaster-like device enables farmers to transfer shallow groundwater to their fields by stepping up and down on pedals that drive the pump.

Like Rajendra Singh, Polak is convinced that farmers must have a stake in the technology that brings them water. Polak is now the full-time head of IDE, which has a staff of 542 working in seven countries. The organization sells treadle pumps through its own network of local distributors, usually for less than a hundred dollars. Polak's ultimate goal, indicative of his penchant to think big, is to bring treadle pumps or low-cost drip irrigation to 30 million farm families in the developing world.

His efforts in sub-Saharan Africa recently brought him to Zambia. I joined him there as he investigated the irrigation potential of seasonal wetlands called *dambos*, from which water can be easily extracted by a treadle pump. Polak and his staff had estimated that 500,000 farmers living near dambos and other shallow water sources in sub-Saharan Africa could use treadle pumps for irrigation, and what he saw in Zambia did not disabuse him of that notion. Traveling from Lusaka to Victoria Falls in the south, Polak met dozens of farmers using buckets to water their fields. It is a backbreaking, inefficient way to irrigate, and the farmers told Polak they would welcome a treadle pump to reduce the drudgery and increase production.

Evidence of what a treadle pump can do in Africa was on display in the countryside around Katuba, an area of rolling savanna and open woodlands. Most villagers there earn less than a dollar a day, and they live in clusters of grass-roofed mud huts, around which they cultivate small plots of corn, Zambia's staple food. The surrounding hills are dotted with acacias and graceful mopani trees.

Late in the day, with thick white clouds sailing across the sky, Polak stopped at several huts owned by two brothers, Noah and Shadreck Phiri. Short, tautly muscled men in their 30s,

Relying on a paltry 12 inches of annual rainfall for 60 percent of its water, Jordan builds its dams on hope (left). Most of its rivers are little more than channels for seasonal rains, and if the rains don't come, the reservoirs don't fill. Last year in Matamoros, Mexico, the overused Rio Grande dropped below the city's water intake pipes, but that problem was temporary. With little waste-water treatment, the city's canals (above) fester with sewage and industrial pollution.

the Phiris were among 2,000 Zambians who have bought IDE treadle pumps over the past five years. Polak greeted the brothers warmly and pulled out a clipboard. With his gray hair and gentle demeanor, he cut a grandfatherly figure, but, as I quickly learned, he is a senior citizen with a workaholic edge. He skipped lunch as he led his entourage around for hours under the scorching midday sun; at night, as he was driven to the next town, Polak would fall asleep in mid-sentence, nodding off during a discourse on Zambian agricultural markets.

Now he launched into a 15-minute interrogation, and it soon emerged that the Phiris had been struggling in their pre-pump days, relying solely on bucket irrigation. The pump, which they bought two years ago, enabled them to expand their fields to about 1.5 acres and grow valuable cash crops, such as baby corn, green beans, and paprika peppers. Their annual income had tripled to $400 apiece. Now they can feed their children more meat, pay their school fees, and replace the earthen floors of their huts with concrete. The brothers told Polak they had visions of cultivating more land, hiring laborers, and paying to bring electricity to their homes. "I want to build a very nice house, and put sheet metal on the roof instead of grass," said Shadreck.

The treadle pump, which had a blue metal frame and two-by-fours as pedals, was sitting in the doorway of Noah's hut. It was summer —the rainy season in southern Africa—but rain had been scarce, and Noah was irrigating his fields several times a week. Two of his daughters picked up the pump and carried it to the dambo, which was 150 yards wide and thick with reeds and banana plants. They hooked one end to a pipe that extended from a shallow, open well at the edge of the dambo and connected the other end to a 50-yard piece of black plastic pipe that ran to a field of Chinese cabbage. Noah placed his bare, callused feet on the two-by-fours and began high-stepping in a steady rhythm that he can maintain for the several hours needed to irrigate

High Cost H_2O

Want clean drinking water in Matamoros? You may have to get out your pesos. Many people here, like a fourth of city dwellers in the developing world, must buy it at inflated prices. Free water can be even costlier. Ramjan Mondol (right) in West Bengal, India, is only 38 but can't work his farm anymore because he's slowly dying from arsenic poisoning. Decades ago, development agencies touted shallow wells as safe alternatives to dirty surface water, but naturally occurring arsenic made many of them toxic. Victims number in the mill

his fields. Water began gushing onto the light brown earth, splashing the cabbage leaves.

Polak cites estimates that sub-Saharan Africa contains 20 million acres of dambos. Scientists are just beginning to study the impact of irrigation on these wetlands, but he believes that treadle pumps, which withdraw far less water than motorized pumps, do not seriously damage dambos. The potential benefits, he said, are immense.

"Everything that has happened to these guys is because of water," he told me after visiting the Phiris. "It's not that water wasn't available. They just didn't have a good way of getting it to their fields. To me, watching that pump spitting water today, knowing it was adding to that family's productivity . . . I love it. There's nothing more fulfilling."

IF THE PHIRI BROTHERS are at one end of the spectrum of the world's irrigators, then Kallie Schoeman must surely be somewhere near the other. A sixth-generation Afrikaner, Schoeman presides over South Africa's largest family-owned citrus farm, an operation that covers 4,400 acres in the fertile, heavily irrigated Olifants River Valley. The Schoeman farm has 500,000 citrus trees that annually produce 175 million oranges and lemons for export to 32 countries. At the heart of this flourishing enterprise is a sophisticated irrigation system that points the way to the changes farmers must make as water becomes scarcer and more expensive.

Since joining the family business 27 years ago, Schoeman has helped introduce a succession of irrigation technologies. When he began, the farm simply opened the sluice gates of irrigation canals and flooded the citrus groves, a highly inefficient system still common in the world today. In the 1980s more efficient sprinklers were introduced. Now Schoeman is steadily replacing the sprinklers with super-efficient drip irrigation, which "gives the trees exactly what they need every day," he said, by parceling out small amounts of water to each tree. As Schoeman has used ever more efficient irrigation systems, the farm has quadrupled the production of fruit per acre while actually using a third of the water.

The nerve endings of his present system are yard-long computerized probes that the irrigation manager, Jaco Burger, places in the soil beneath tidy rows of trees. Every 15 minutes, via solar-powered radio, the probes relay data about soil moisture to the farm's computers. Based on that information and the time of year—the trees need different amounts of water during the different stages of fruit development—Burger adjusts the rate at which water, mixed with fertilizer, flows. Standing in a hundred-acre field, surrounded by about 35,000 young orange trees, I watched as water trickled from a narrow tube into the soil below a sapling—one of three 20-minute feeding pulses the trees would receive that day.

Burger said commercial farmers will have to continue making such technological leaps as water becomes costlier. As he put it, farmers in the Olifants have been paying "next to nothing" for water. But that, and many other aspects of water in South Africa, are beginning to change. In 1998 the government passed the National Water Act, which is designed, in part, to redress the legacy of apartheid by assuring that everyone has equal access to water. The law looks at river basins as ecological systems, requiring that basic human needs, such as clean drinking water, and basic environmental needs, such as maintaining stream flows, be met before giving water to industry and agriculture.

"We know agriculture won't get more water," said Schoeman. "We will get less, it will become more expensive, and we will have to use it more efficiently."

Another South African with an obsessive desire to make the most of every drop of water is Neil Macleod, the man in charge of providing water and sewerage services to roughly three million people in Durban. A plain-spoken, unassuming civil engineer of 50 with a brush mustache, Macleod has drastically reduced waste in the city's water system while simultaneously improving water delivery to the urban poor.

Taking over as executive director of Durban Metro Water Services in 1992, two years before the end of apartheid, Macleod encountered an abysmal situation. Durban had one million people living in the city proper and another 1.5 million people, almost all black, who had

since lost their fear of dying from a drink of water.

MAKING DO IN AN ARID LAND

In summer the taps run only ■ day or two ■ week in Amman, Jordan, so residents have to store water in rooftop tanks. The rations will likely get even tighter in years to come: Jordan's population is on track to double within a quarter century.

moved into shantytowns or were living in housing projects just outside the city. Macleod and his engineers determined that 42 percent of the region's water was being wasted because of broken water pipes and mains, leaky toilets, and faulty plumbing. Of particular concern were two large districts, with a combined population of 500,000, where up to 87 percent of the water was being lost due to leaks and other wastage.

"People were not paying for water, and if a shower or toilet was broken, it just ran," recalled Macleod. "We inherited 700 reported leaks and bursts. The water literally just ran down the streets. Demand for water was growing 4 percent a year, and we thought we'd have to build another dam by 2000."

Macleod embarked on a crash program to tame the colossal losses. His crews began repairing and replacing mains. They put meters on residences, replaced four-gallon flush toilets with two-gallon models, and retrofitted wasteful showerheads and water taps. To ensure that the poor would receive a basic supply of water, Macleod installed tanks in homes and apartments to provide 50 gallons of water a day free to each household.

Water consumption in metropolitan Durban is now less than it was in 1996, even as 800,000 more people have received service. By cutting water use—daily consumption in the most wasteful districts has been reduced by more than half—Durban's conservation measures paid for themselves within a year. Plans to build a costly new dam have been shelved, and Macleod is confident that no new dams will be needed in the coming decades, despite the expected addition of about 300,000 users.

Around the world other water conservation programs have also achieved impressive results. U.S. cities such as Boston, Seattle, and Albuquerque have reduced demand 20 to 25 percent in part by repairing aging infrastructure and retrofitting plumbing fixtures in homes. Indeed, per capita indoor water use in the U.S. has dropped since 1980. Outdoor use, however, has risen, probably because so many people have installed automatic lawn sprinkler systems. Today, the average American uses 101 gallons of water a day—more than 15 times that used by many people in developing countries.

In Durban, Macleod has now turned to water recycling. With the region's water supplier increasing prices, he decided to take about 10 million of the 125 million gallons of wastewater the city treated daily and use it again, piping it to industries nearby. The French firm Vivendi, one of a growing number of companies involved in water management, built a sophisticated treatment facility next to one of Durban's wastewater plants. Operators of a nearby paper mill and refinery are satisfied because they pay almost half price for the recycled water, and Macleod is pleased because the recycling has cut metropolitan water demand by about 5 percent.

Desert Mirage

LAS VEGAS, THE DRIEST STATE'S

In this city of excess and illusion, water is no exception. At the Bellagio Hotel, 27 million gallons of water dance to show tunes through choreographed nozzles in an eight-acre artificial lake. With nearby Hoover Dam providing precious Colorado River water, Las Vegas residents—and their green lawns—use more than double the water most Americans do.


DALLY

On a steamy afternoon Macleod took me to the plant, where I watched wastewater turned into clean water in just 12 hours as it passed through sand and carbon filters, was treated with ozone, and dosed with chlorine. I finished the tour on the roof of the Vivendi facility, where glasses of water were arrayed on a table. I took several sips and could not discern a difference between the municipal drinking water and the treated wastewater. Though intended for industrial use, the recycled water I sampled was pure enough for drinking.

The sweet taste of the treated wastewater was a taste of the future, for in the years to come water recycling will likely become increasingly common. Indeed, in the neighboring desert nation of Namibia, Vivendi is a partner in a plant that turns wastewater directly into drinking water for the capital, Windhoek, refining the water even one step further than Durban's recycling operation. Windhoek's wastewater-to-drinking water plant is the only such facility in the world, but Stephen McCarley, the general manager of Vivendi's Durban operation, is confident it won't be the last.

"As water goes up in price, the opportunities to do this kind of treatment will grow," said McCarley, my guide on the tour of the Durban plant. "From the technological point of view, you can do anything with water. As the resource is more constrained, people will have to get used to recycling."

Noting the purity of the treated wastewater,

Macleod chimed in, "Go to many areas of the world, and they're drinking far worse water than this."

MACLEOD would not have to go far. His own province of KwaZulu-Natal was fighting a cholera outbreak, proof that post-apartheid South Africa—despite its water pioneers and progressive water legislation—still has a huge gap between blacks and whites. The South African government has succeeded in bringing safe drinking water to millions of its citizens in recent years, but about 7 million of the country's 44 million people still lack access to clean water within 200 yards of their homes. Drinking contaminated water, often from streams, was behind the most recent outbreak, which has killed 289 people in KwaZulu-Natal and infected 120,000 others since August 2000. Those deaths were among the 18,000 that occur in South Africa annually from diarrhea-related ailments, most of which are waterborne.

The outbreak was centered in the hilly, picturesque Ladysmith region, where whites typically have water and sewerage systems, but where 85 percent of blacks lack proper sanitation and 60 percent do not have access to the South African government's minimum recommended quantity of clean water: 25 liters (6.6 gallons) per person per day.

I visited rural health clinics where patients lay under canvas tents, receiving rehydration fluid, intravenously and orally, to counteract

The Dam Dilemma

In Tehri, India, pipes that will feed hydroelectric turbines hint at the scale of what will soon be one of the world's tallest dams. The reach and benefits of dams are enormous: The world's 45,000 large dams catch 14 percent of all precipitation runoff, provide water for up to 40 percent of irrigated land, and give some 65 countries more than half their electricity. But the costs are also enormous. In India alone, up to 38 million people have been displaced by large-scale dams. This group of Tehri women, forced to leave their homes, protest the compensation the government has offered them.

the cholera infection, which can cause rapid death from diarrhea-induced dehydration.

In the Mhlumayo area, along a feeble stream called Impundu, I met the family of one of the victims, a 59-year-old farmer named Mkhanyiswa Sithole. I found his wife and several of their eight children amid a cluster of huts perched on a hillside. Khithiza Sithole, 53, was a regal woman in a long, blue mourning dress. She sat on a grass mat and recounted how her husband fell ill around 4 a.m. on November 26, 2001.

"The diarrhea started, and he was crying about the pain in his stomach," said Mrs. Sithole. "He was vomiting and having bad cramps. He kept crying out."

Shortly after noon the family drove him to a rural clinic, where he was given intravenous fluids. His condition worsened, however, and he was transferred by ambulance to Ladysmith Hospital. There, despite continued treatment, he died around 11 p.m., less than 24 hours after falling ill. The family suspects that he may have contracted cholera after drinking directly from the Impundu. Several other people in the village also died.

"I am struggling after his death," said Mrs. Sithole, whose family survives by virtue of a small vegetable plot, cattle, and goats.

A few yards away, in the middle of a corral made from woven saplings, was Mr. Sithole's grave. Following Zulu custom, he was buried in a place of honor, among the family's livestock, and covered with a mound of rocks.

IN WESTERN EUROPE and the United States people have long since lost their fear of dying from a drink of water. Nevertheless, water use there poses an altogether different threat, this one to nature itself.

In the Castile La Mancha region of south-central Spain, a 74-year-old former fisherman, Julio Escudero, has seen one of the country's prized wetlands altered beyond recognition. Escudero was born on the banks of Las Tablas de Daimiel, a freshwater marsh at the heart of a sprawling, 60,000-acre mosaic of wetlands

Low on water but not options, St. Petersburg, Florida, has been a conservation pioneer, stocking parks with drought-tolerant plants (left) and recycling its wastewater. Used for irrigation and industry, treated wastewater may one day meet a fifth of the city's needs. Worldwide, two-thirds of urban wastewater doesn't even get treated, much less recycled, but that could change. Santiago, Chile, which just opened a treatment plant (above), will treat all its wastewater by 2009.

in La Mancha. He was part of a small fishing community of 300 families around Daimiel that harvested primarily carp and crayfish. Escudero sometimes fished on the picturesque Guadiana River and fondly recalls an area called Los Ojos—"the eyes"—where large, underground springs bubbled up into the limpid waterway.

"We could see all the water rising from the bottom in big columns," said Escudero. "I would sit in my boat six or seven meters away and just watch the water coming up. Now it looks like the moon."

Los Ojos is no more: The underwater springs dried up in 1984. That stretch of the Guadiana —a six-mile portion above Daimiel—also has disappeared. Where there was once a gentle, percolating river, 30 yards wide, there now are a road, fields of grain, and rocky portions of riverbed. The 60,000 acres of original wetlands, superb habitat for cranes and waterfowl, have shrunk to a core area of about 14,000 acres.

What happened? An onslaught of irrigated agriculture. La Mancha has witnessed an explosion of well digging in the past 40 years that has lowered the water table and reduced streamflows. The number of irrigated acres—farmers grow alfalfa, barley, corn, wheat, and sugar beets, among other crops—has soared from 60,000 in 1960 to 500,000 today, and the number of wells has grown from 1,500 to an official count of 21,000. Some experts say the total number, including illegal wells, could surpass 50,000.

"As long as you have so many wells sucking out the groundwater, Las Tablas won't come back," said Escudero, the last commercial fisherman to work in Las Tablas de Daimiel. "I see no solution. I see a cadaver."

Spain is now at a crossroads. Like another semi-arid region, southern California, this Mediterranean country has built dams—about 1,200 major ones—and piped water long distances to supply farms and municipalities. Now a new National Hydrological Plan calls for transferring nearly 1.4 billion cubic yards of

water a year from the Ebro River in the north to burgeoning regions along the Mediterranean coast. The plan has stirred controversy, with a growing number of opponents questioning the cost, economic and environmental, of such massive schemes. The government says the multibillion-dollar project is necessary to halt the overexploitation of southern aquifers. But environmentalists contend that the Ebro has already lost half its flow because of irrigation and dams and will shrink even further, accelerating the decline of the Ebro Delta, a prime Mediterranean fish nursery and vital bird habitat.

Spanish environmentalists say it is time to stop draining the country's wetlands and to curtail agricultural subsidies that underwrite the cultivation of irrigated crops, encouraging profligate water use. Spain's greatest wetland—Doñana on the Atlantic coast, home to half a million overwintering birds and a stopover for six million migratory birds—has seen its natural marshlands cut from about 370,000 acres to 75,000 because of agricultural development and water engineering projects. (Despite such losses, Doñana still attracts large numbers of flamingos, white storks, glossy ibises, greylag geese, and other waterfowl because the wetlands were converted to flooded rice fields or aquaculture ponds.) The government and conservation groups have now embarked on a major reengineering program—similar to an eight-billion-dollar plan to restore water flows in the Florida Everglades—that will revive some of Doñana's marshes.

"Water is controlled by the strawberry growers, the rice growers, the tourism hotels," said Beltrán de Ceballos, head of the Doñana Foundation, a conservation group that has begun restoring wetlands. "It's controlled by everyone, but what doesn't get taken into account is water for the birds."

THIS CENTURY many countries will face the dilemma being confronted by the people of Spain: how to balance human needs with the requirements of natural systems that are vital to sustain life on Earth. Some are hoping that new technologies, such as the desalination of seawater, will solve the problems faced by a water-stressed world. Yet only two-tenths of one percent of the water people use today is desalinated, and most of that is produced in desert kingdoms and island nations. Desalination is sure to become more common—plants are now under construction in southern California and Florida—but some experts remain skeptical that the process will become widespread, because of its cost.

"There is a kind of a silver bullet belief about desalination," said Sandra Postel of the Global Water Policy Project. "But the fact is, water conservation is where the big gains are to be made."

Indeed, during my travels I came away most impressed with the ingenuity of people like Rajendra Singh and Neil Macleod. The choice of heeding or ignoring such innovators is a stark one, as I saw in western India. In Gujarat's largest city, Ahmadabad, the Sabarmati River once flowed perennially through the heart of town. Today, due to the construction of a large dam and overpumping of the region's aquifers, the river only runs during the monsoon floods in summer. The rest of the time the Sabarmati is what I saw last February—a dry, dust-shrouded scar inhabited by tens of thousands of people living in fetid squatters' shacks.

A few hundred miles to the north, in Rajasthan's Sariska Tiger Reserve, is another vision. There, in an arid mountain valley where residents once walked two miles to fetch water, Rajendra Singh has helped villagers construct several low dams. Where once there was a dry creek bed, now there are reservoirs. Lined by palms and looking very much like an oasis, their waters offer people what they have lacked for decades—a cool drink, close at hand. □

WATER BLUES OR A BLUE REVOLUTION?

Water is momentarily plentiful for ■ boy in the gush of a Calcutta well, but as he grows into a man, India's water situation—and the world's—will likely go from bad to worse. Another two billion people will need food and water by 2025. Will the planet have enough water? That depends on how wisely it's used.

ON OUR WEBSITE

Go behind the scenes in the story of water with Fen Montaigne and Peter Essick. Find zoom-in images, links, and research sources at **nationalgeographic.com/ngm/0209**.

getting more out of each drop of water is imperative.

By John G. Mitchell

Photographs by Jay Dickman

Down the Drain?

The Incredible Shrinking Great Lakes

The world's largest freshwater system has shrunk before, but never so quickly. In Traverse City, Michigan, a family business at a crossroads—or what once was its bottom—reflect how the Great Lakes tourist economy has stopped in sync with falling water levels. And the harder the waters recede, the higher anxiety rises

Casting a wary eye on Lake Huron

The waterline along Georgian Bay in Ontario, Canada, has dropped more than 40 inches in recent years—a legacy of drought and warmer temperatures. Sportfishermen fear for the future of species that spawn in its coastal streams.

A shallow lake in deep water

Miracle worker? Nope. Just a fellow on an emerging sandbar in Lake St. Clair, where rains of biblical scope would be needed to significantly raise water levels. Periodic dredging here keeps large ships moving between Huron and Erie.

It takes a long time to learn how to get along with a lake. A decade isn't half enough. A generation might do. Then, if you have lived that long beside a lake the size of Michigan, you begin to understand that there's something about the fluctuating level of the water that makes no apologies for any inconvenience it may cause. Here is a wide sandy beach; there, a cottage perched at the lip of a crumbling bluff. Now you see them, now you don't. It's enough to keep a person guessing. The lake couldn't care less.

On the Old Mission Peninsula in Lake Michigan's Grand Traverse Bay, Ted Cline gave up guessing years ago. Since 1957 he and his wife, Jean, have lived here in a home overlooking the bay. From the edge of the lawn, steps go down to a fine sand beach, almost to the water when the level's up. But not long after the Clines moved in, they had to take a walk to wet their feet—the level of Lake Michigan had fallen lower than at any time since surface measurements were first recorded in the 19th century. A shade over 20 years later the lake was up again, higher than it had been in a century, lapping at the foot of the Clines' steps.

Last summer I stood with Cline above the lake and saw how it might have looked back in that earlier record-low time of 1964. For now, after years of drought and simmering annual temperatures, the levels of the Great Lakes had fallen once again, all the way from Duluth, Minnesota, to Kingston, Ontario, at the head of the St. Lawrence River. This is not just a matter of inconvenience to a hundred thousand riparian landowners along U.S. and Canadian shores, though more than a few of them are being put to the expense of extending their docks. It is a matter of concern to the multitudinous cities and farms dependent on lake water, to the boating and fishing segments of the region's multibillion-dollar tourism industry, and to the operators of deep-draft ships that ply these inland ports and waterways to hitch North America's heartland to the markets of the world.

And right here the wide, weedy beaches and rocky shoals of the Old Mission Peninsula said it all: Another couple of years of climatic deprivation and the greatest of these lakes might well bottom out at levels lower than any recorded in historic times.

"Oh, the lake will come back up someday," Cline said. A retired surgeon and World War II leatherneck dive-bomber pilot, he has seen much of the upper Great Lakes from the cockpit of his private plane, flying aerial photography assignments for books and magazines. Now, at the top of the steps above his dehydrated beach, I could only say to Cline, "I hope you're right."

THE GREAT LAKES—Superior, Michigan, Huron, Erie, Ontario—along with the rivers, channels, and lesser lakes feeding or draining them, constitute the largest surface freshwater system on Earth. The system is spread across more than 94,000 square miles and drains a much larger watershed that embraces parts of eight states and two Canadian provinces. If only the Earth were flat and the lakes adaptable as buckets, there'd be enough H_2O here to flood all the land of the Western Hemisphere under two feet of water.

A complex hydrologic cycle orchestrates the volume of water contained in this system at any one time. And the volume, of course, dictates the levels.

The cycle begins in the clouds. Rain and snow fall across the lakes and the surrounding watershed lands, where runoff replenishes the system's tributaries and aquifers, and they, in turn, replenish the lakes. But that's only half

Short on snow, long on thirst

A bare gauge tells the tale: Ontario's snowpack near Lake Superior has declined in depth and density, with snowmelt running below average in three of the past five years. Much of Canada's industry lies within the Great Lakes watershed, ▬ does nearly a third of its population, including more than four and a half million people in Toronto (left).

of the cycle. The other half takes some of the water away through evaporation from the surface of the lakes and transpiration from terrestrial plants throughout the watershed. When the inflow from precipitation and runoff is exceeded by the loss of water due to evaporation and transpiration and outflow down the St. Lawrence River, then the levels of the Great Lakes have nowhere to go but down.

Evaporation seems to be winning. By most accounts six of the warmest years on record in this region occurred in the past decade. That not only increased the rate of evaporation in the summertime but also raised it in the winter by depriving the lakes of their normal ice cover. Ice inhibits evaporation. With the exception of Erie, the shallowest of the five, the Great Lakes rarely freeze shore to shore but often ice up in their bays and mid-lake areas. In recent years, however, ice cover did not occur in some places accustomed to freeze or, if it did occur, came in later and went out earlier than usual, which raises the question of global warming.

Lake levels throughout the system are also hugely influenced by the annual snowpack and subsequent snowmelt runoff, especially in the headwater country of Lake Superior. Over three of the past five years, snowpacks around the three upper lakes have yielded runoffs significantly below average. "Springtime has been starting six weeks earlier than normal around the northern lakes," said Roger Gauthier, a senior hydrologist with the U.S. Army Corps of Engineers in Detroit. "The only snow we've seen this year has been lake-effect snow—moisture that evaporates off the lakes and then falls as snow, sometimes outside the basin. That doesn't help their levels any."

BEHOLD THE OUTLINE of Lake Superior, and you behold the west-facing head of a wolf. At the snout sit the port cities of Duluth, Minnesota, and Superior, Wisconsin (combined population 118,500), which move up to 40 million metric tons of cargo eastward through the Great Lakes every year. Behind the snout our limnetic wolf is getting thirsty.

On the day of my visit two big ships were loading wheat for export to the Mediterranean, a third was taking on Midwest soybeans for a trip to the mouth of the St. Lawrence Seaway, and the holds of a fourth, the *Burns Harbor*, were inhaling 57,000 gross tons of iron ore pellets for delivery to the steel mills near Gary, Indiana. Nearly two-thirds of all steel produced in the United States starts as iron ore here on the shores of Lake *(Continued on page 46)*

Lake Nipigon

ONTARIO

Thunder Bay

BOUNDARY WATERS CANOE AREA WILDERNESS

ANADA

Sault Ste. Marie

LAKE SUPERIOR

Grand Marais

Isle Royale (Mich.)

Houghton

Harbor

Baptism River

Castle

MINN.

Beaver Island

Point

Grand Traverse Bay

Old Mission Peninsula

Duluth

Superior

WISCONSIN

Green Bay

Suamico

Traverse City

LAKE MICHIGAN

Milwaukee

Gary

Calumet Harbor

Chicago

ILLINOIS

Illinois River

How the Lakes Shrink

1 Precipitation

the watershed

the lakes of

snow

lake-feeding tributaries

2 Temperature

Warmer

both evaporation

lake

trees and other plants

the aquifers beneath them. In w

reduced

further increases evaporation.

3 Consumption

Most lake water withdrawn for municipal

industrial uses returns to the system

in the flow of

sends its

draw on to the

sippi after treatment

Fears and Fluctuations

While water levels are not as low as they have been at various times during the past century, the tremendous speed of the recent decline worries experts.

LAKE SUPERIOR 600 ft (183 m) above sea level

LAKE MICHIGAN 577 ft (176 m)

ANNUALLY AVERAGED WATER LEVEL

Lowest level (1926): 600.1 ft (182.9

by the

Mackinac, Lake

and Huron form a single body of water with

water

Year

1900 1920 1940 1960 1980 2000

1900 1920 1940

(563 km)

(494 km)

(257 km)

(190 km)

Avg. depth

(147 m)

(85 m)

(406 m)

(282 m)

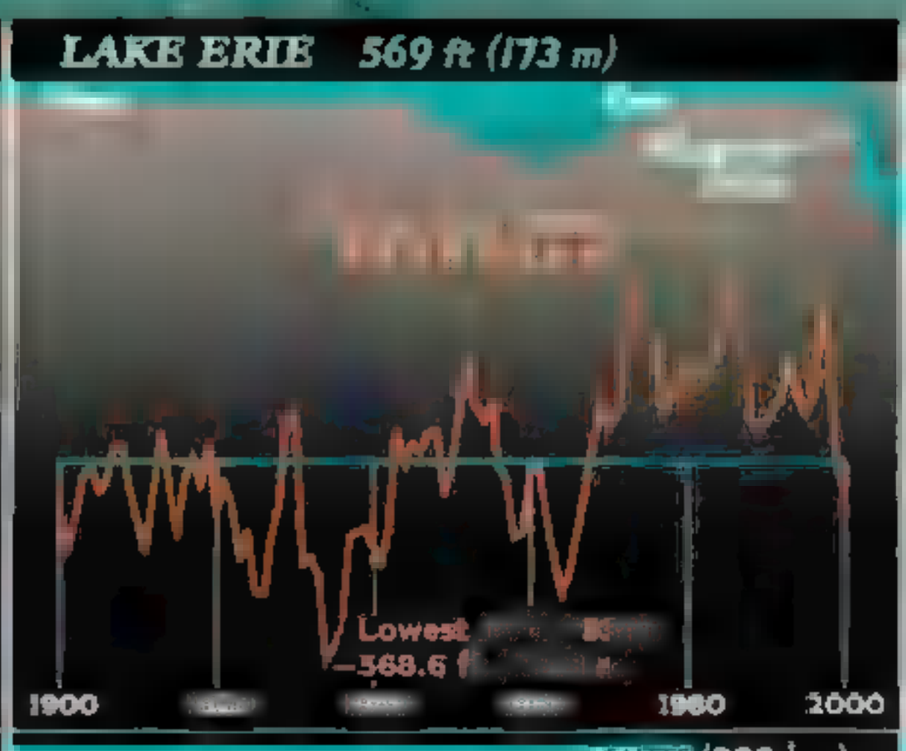
2,900 mi² (12,088 km²)

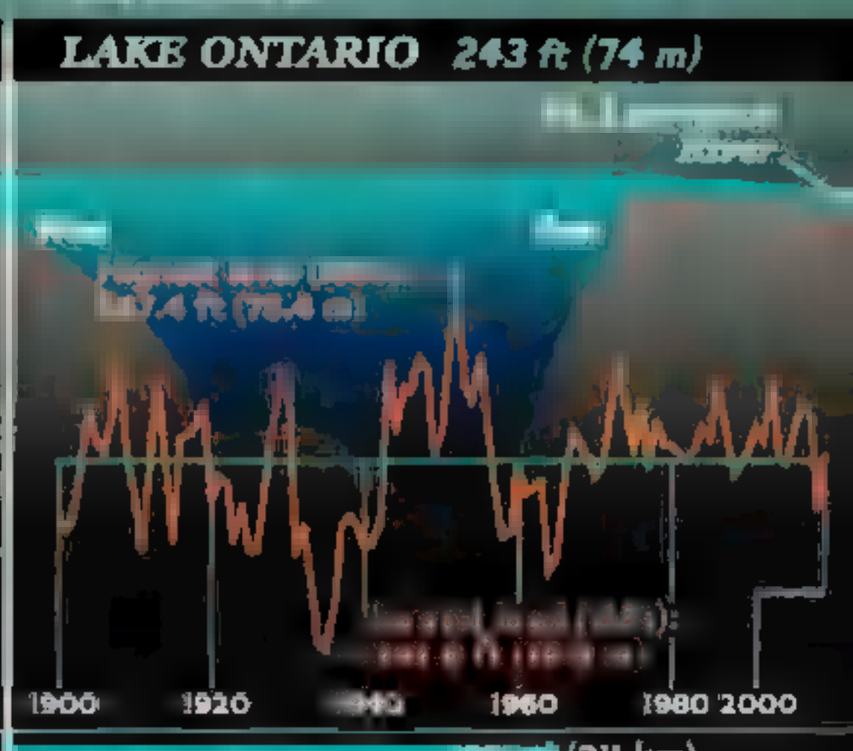
mi³ (4,918 km³)

Feeling the Heat

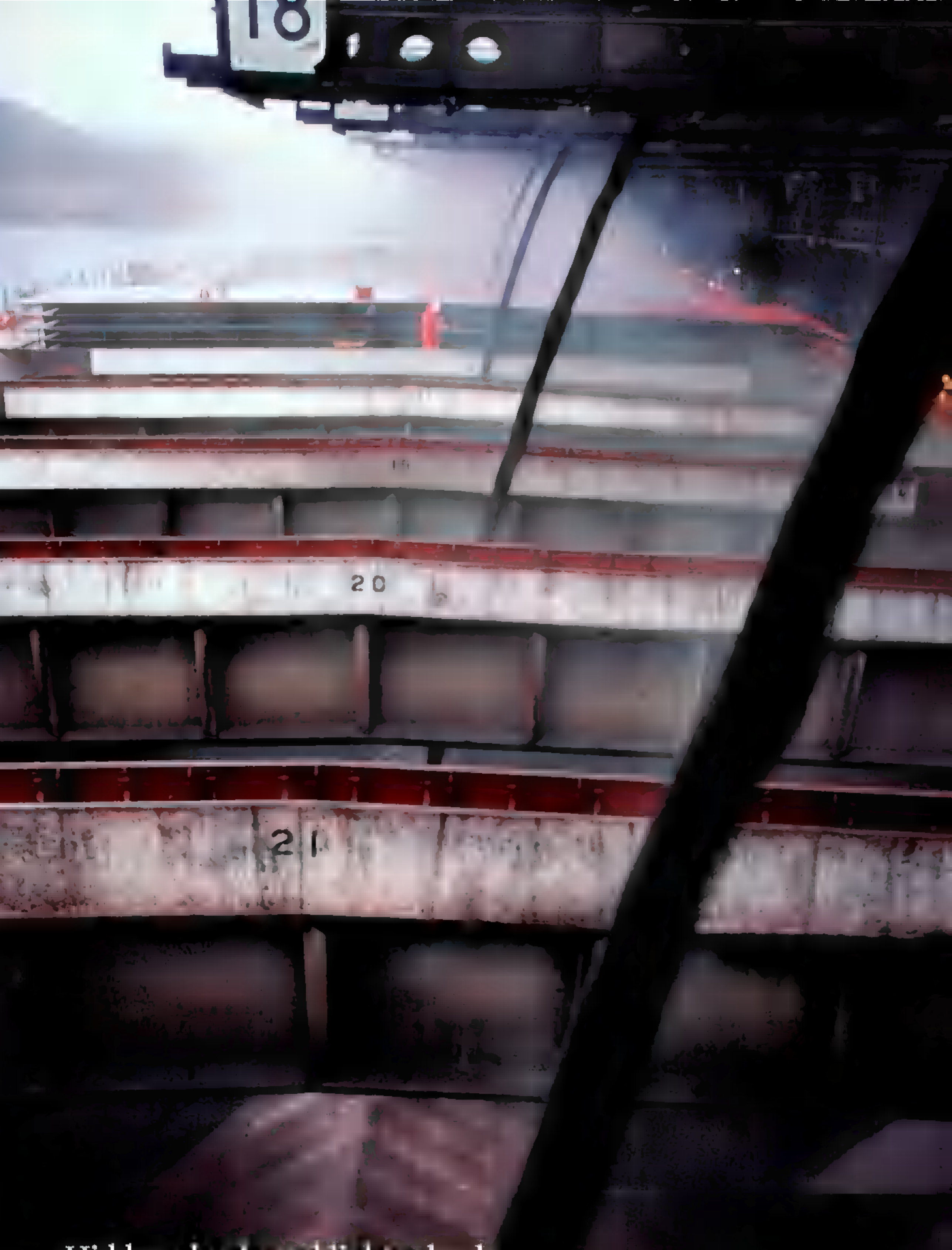
Last year the aggregate level of the five Great Lakes—which hold a fifth of the world's surface fresh water—plunged to its lowest point in more than 30 years. Superior and Huron hit record lows. Despite slight increases recently, the aggregate level is still down. Scientists attribute the loss to a new cycle of dry, warm weather across the region's 295,000-square-mile watershed.

QUEBEC
St. Lawrence River
Kingston
St. Marys River
Rock Cut
Manitoulin I.
Georgian Bay
Straits of Mackinac
LAKE HURON
Petoskey
Toronto
LAKE ONTARIO
ONTARIO
NEW YORK
Buffalo
Niagara Falls
MICHIGAN
Muskegon River
LOWER
PENINSULA
Grand Rapids
Lake St. Clair
Detroit
LAKE ERIE
Erie
PENNSYLVANIA
Cleveland
OHIO
Great Lakes Watershed
INDIANA





SEAWIFS IMAGE GREAT NASA/GOODARD SPACE FLIGHT CENTER AND ORBIMAGE; ENVIRONMENTAL RESEARCH LABORATORY, NOAA.
NATIONAL GEOGRAPHIC



Hidden shoals and lighter loads

A [illegible] near Duluth, Minnesota. For every inch lost from the lake's surface, carriers must trim tons off their loads (and millions off their profits) for fear of grounding. In the newly shoaled waters ringing isles in Lake Michigan, many a skipper has "[illegible]" bottom.

Hip deep in trouble

Towboat operator Ron Cunningham wades to the rescue of yet another craft that's run aground in Lake St. Clair near the Detroit suburb of Grosse Pointe, which boasts the nation's highest per capita ownership of recreational boats.

Superior. At Duluth the tonnage of iron ore is exceeded only by that of coal, which flows to the waiting ships in 123-car trains, a thousand miles from the bituminous seams of Wyoming's Powder River.

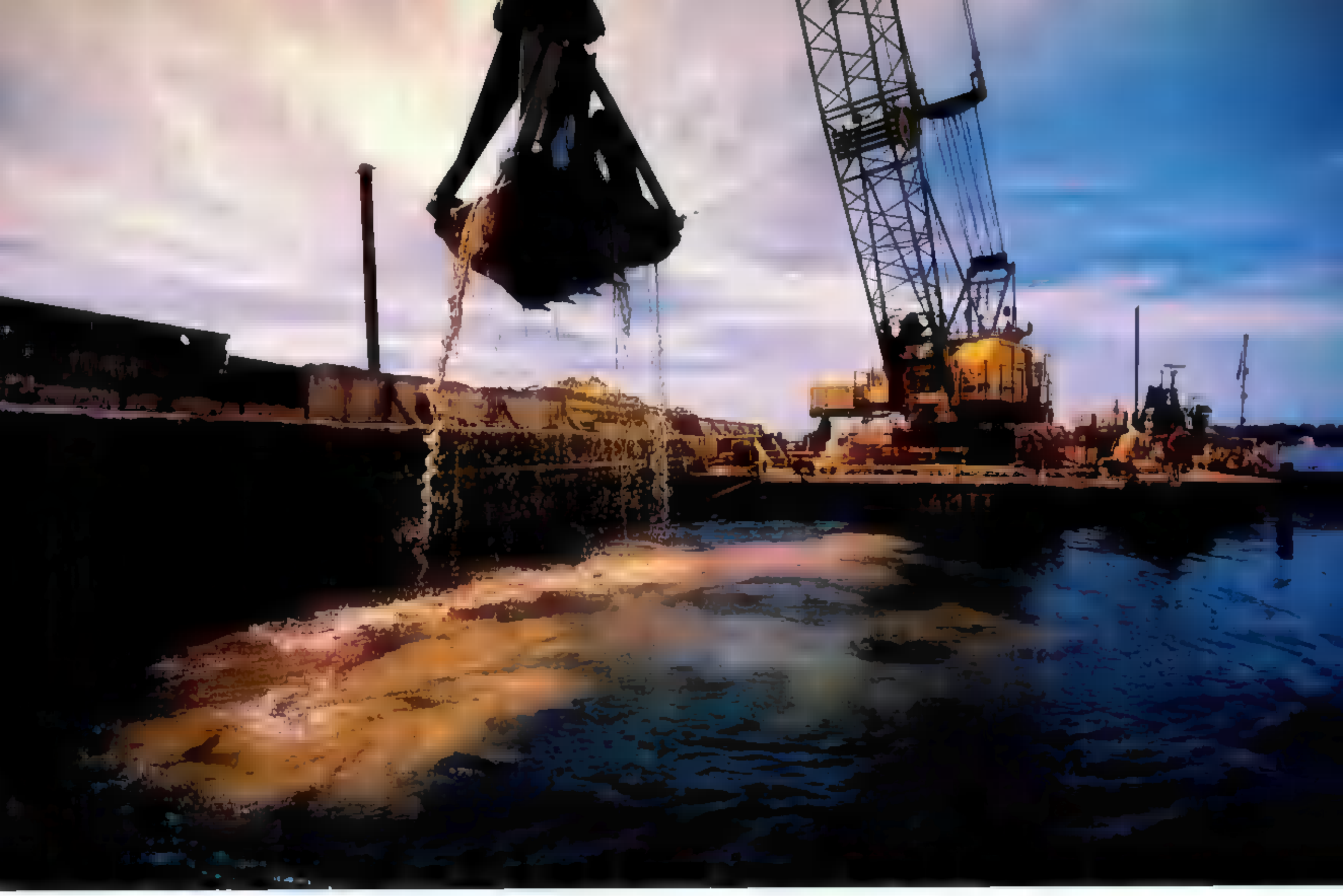
Water levels can have a prodigious effect on Great Lakes shipping. According to Davis Helberg, executive director of the Duluth Seaway Port Authority, for every inch of ship's draft clearance lost to low water in the shallower channels, such as the St. Marys River between Lake Superior and Michigan-Huron, a carrier must reduce his cargo by as much as 270 tons or risk the danger of running aground. For the owners of these big lake freighters—longer than three football fields—the collective cost of low water is estimated at several billion dollars a year.

Albert Tielke, captain of the *Burns Harbor*, a thousand-footer, told me about a ship that tore a hole in its bottom in Lake Michigan's Grays Reef Passage, east of Beaver Island, a few years ago. "They had to put her in dry dock," he said. "And another ship 'sniffed' the bottom of Calumet Harbor once or twice."

Then Davis Helberg, the port director, put in. "Don't forget the Rock Cut in the St. Marys River," he said. "That's what you have to look out for. There's no forgiveness down there in that cut."

There's not much more forgiveness in the harbors, marinas, and tributary rivers that provide the venue for Great Lakes recreational skippers and sportfishermen. Up the north shore of Superior, up beyond Castle Danger and Beaver Bay, the Baptism and Temperance Rivers looked sluggishly low. I stopped in Grand Marais to check out Wilderness Outfitters, a sales and rental shop catering to the paddling clientele of the tributary Boundary Waters Canoe Area Wilderness. Had the lowered level of Superior affected business in any way? "The drought has," said the outfitter. "Some of our rental canoes are coming back here with a lot more dents than ever before."

Navigation can get tricky for yachtsmen and sailors as well. At the Irish Boat Shop in Harbor Springs, Michigan, the shrinking level of the



lake has forced David Irish to dredge his marina's channel three years in a row. "It's a fast way to get rid of your cash," he said.

THE TIP OF THE MITT Watershed Council is a nonprofit organization dedicated to protecting northern Michigan's water resources. Its offices are located in Petoskey, up near the tip of the mitten some people see when they look at a map of Michigan's Lower Peninsula. After the bad economic news I'd been hearing around the lakes, I wanted to learn a bit about environmental impacts and expected that news would be bad as well. At Tip of the Mitt it wasn't.

"Periodic low water levels are important," Wil Cwikiel was saying. Cwikiel is the council's coastal specialist. "Wetlands and exposed bottomlands are among the most biologically productive ecosystems in the Great Lakes," he said. "We've seen extensive use of these exposed flats by shorebirds and other wildlife. Exposed, the land sprouts new vegetation. And when the levels rise again, there's good habitat for the aquatic creatures. If we're to retain a productive fishery in the lakes, we've got to maintain the food chain fish need to survive."

Cwikiel lamented the tendency of many people to yearn for a static system in which the water levels might be stabilized. "It won't happen," he said. In fact, the most recent study by the International Joint Commission on the Great Lakes concluded that the costs of engineering works to further regulate the system's flows and levels not only would exceed the benefits provided but also would result in serious environmental impacts.

"If only we could begin to think like a Great Lake," Cwikiel said, "and not worry about how far we'll have to walk on the beach to get to the water. Then we'd realize that in all parts of the levels cycle there are beneficial processes."

While lake levels early this year actually rose a bit, many experts, like Cwikiel, still worry about future levels. What if recent drops have *not* been just part of a natural fluctuation? What if there's truth in what some scientists say about the water levels dropping because of global warming?

"Well," said Cwikiel, "that's the wild card."

I was turning that card over in my mind as I drove north up the lake road toward the ultimate tip of the mitt. Although there is still some uncertainty about the effects of global warming, current studies suggest that under some scenarios the water level of the Great Lakes could be further lowered by three feet or more by the middle of the 21st

Spare the dredge, spoil the propeller

Propellers mangled by hitting bottom signal a dire need for dredging, which is big business nowadays throughout the Great Lakes. Dredging permits issued by the U.S. Army Corps of Engineers have almost doubled in four years to clear harbors, marinas, and key interlake connectors such as the channel at Sault Ste. Marie, Michigan (left).

century. Confronting a number like that, how can anyone think like a Great Lake?

NORTH BY NORTHWEST of Petoskey and Harbor Springs a steep bluff shoulders its way down to Lake Michigan under birches and hemlocks and maples, then plays out across a yellow sand beach that is shown on some maps as Sevenmile Point. Once upon a summertime I played there too; learned how to swim there, how to build castles, how to skip stones. I suspect I was a little afraid of Lake Michigan those days, even from the safety of the beach. The lake looked so huge. Couldn't see across it. Bucking the prevailing winds, you'd have a hundred miles of whitecaps and blue water (someone probably said) before you could haul out over there in Wisconsin. Then I learned in school about the other Great Lakes and how, put together, they contain a fifth of the world's fresh water.

Now that ought to be plenty of water to go around. Right? Probably not.

Regardless of what climate change may have in store for the Great Lakes, there will always be some level of consumptive human use—water that is withdrawn from the system and not returned to it directly. Current withdrawals for municipal drinking and industrial uses amount to barely a drop in the bucket, for most of the water eventually finds its way back to the system after treatment or in the flow of recharged groundwater. The only significant diversion that does not get back into the system is the 2.4-billion-gallon-a-day draw Chicago extracts from Lake Michigan. For the sanctity of its beaches, Chicago posts its treated wastewater into a sanitary canal, which drains through the Des Plaines River to the Gulf-bound Mississippi. This diversion, however, is no great loss to the system because up in Lake Superior it is offset by two positive diversions. These, in effect, pluck water from Ontario's Hudson Bay watershed and transfer it into Lake Superior. On its way south the Ontario water is used to generate hydroelectricity.

Though the United States and Canada have imposed a temporary moratorium on further diversions or bulk exports of water, there's constant fear in this region that some other region with sufficient political muscle—California, for example, or the arid Southwest—might find a way to tap the lakes. And, in fact, the record is replete with attempts to do just that.

In the 1950s a scheme emerged under the grandiose acronym GRAND, the Great Recycling and Northern Development project. The

Iceless in February

An icebreaker meets no resistance as it noses across Lake Erie toward the lights of Cleveland, Ohio. Normally in winter, sheet ice would be edging out from the shore. But ice here has been rare in recent years—a chill omen for the future of the lakes.

idea was to isolate James Bay from Hudson Bay with a dike to keep out the salt water and then, by reversing the flow of some Canadian rivers, pipe fresh water into Lake Huron, where transfers to a thirstier region would be possible. The scheme sank under its own grand weight.

In the 1980s someone came up with the bright idea of tapping the Great Lakes to recharge the thirsting Ogallala aquifer under the Great Plains. The U.S. Army Corps of Engineers said "No." Then in 1998 a deal was almost cut that would have permitted a Canadian firm to ship Superior water for bulk sales in Asia. And earlier this year Nestlé Waters North America received permission to bottle up to 210 million gallons a year from an aquifer north of Grand Rapids that recharges the Muskegon River, a major Lake Michigan tributary.

That one is being challenged in the courts.

Paul Simon, the former Illinois senator, presidential candidate, and author of articles and books about global water shortages, believes it will be only a matter of time before piping bulk exports of water out of the region becomes politically and economically feasible. "Tapping the Great Lakes is going to happen," said Simon, who frowns on the prospect. "If there isn't a big push on desalinization in the West, I'd say it's going to be inevitable."

I thought of Simon's prophecy the afternoon I revisited the wide beach at Sevenmile Point. It was hot. A calm had settled across the water like a tight shroud. No whitecaps, just a flat horizon without a sail, out there at the bottom of the sky near Beaver Island. It occurred to me then that between Simon's grim vision and the wild-card models of global warming, there might not be a whole lot of wiggle room left for learning to live with the natural, cyclical ebb and flow of the Great Lakes.

With that, I found a small, wave-slicked stone and, remembering the barefoot boy at the edge of ■ hundred miles of whitecaps, skipped it toward Wisconsin. □

MORE ON OUR WEBSITE

Concerned about the future of the Great Lakes? Share your thoughts on our forum board and find images and field notes at **nationalgeographic.com/ngm/0209**.

MEERKATS

As adults they're barely a foot tall, even counting their tails. But if helpfulness counted for weight, meerkats would be giants. Nearly a decade of fieldwork in South Africa by my international team shows meerkats to be among the most cooperative mammals on Earth. *Homo sapiens* come close, but only in our best days.

Tall Stand

BY TIM CLUTTON-BROCK

PHOTOGRAPHS BY MATTIAS KLUM

Propped up on kickstand tails, some meerkats chatter and others doze. They start each

day with a sunbath, soaking away the Kalahari Desert's overnight chill. Facing a harsh environment shoulder to shoulder, these small members of the mongoose family live in groups of [redacted] many as 40 animals and defend southern African scrubland ranges covering two to six square miles.

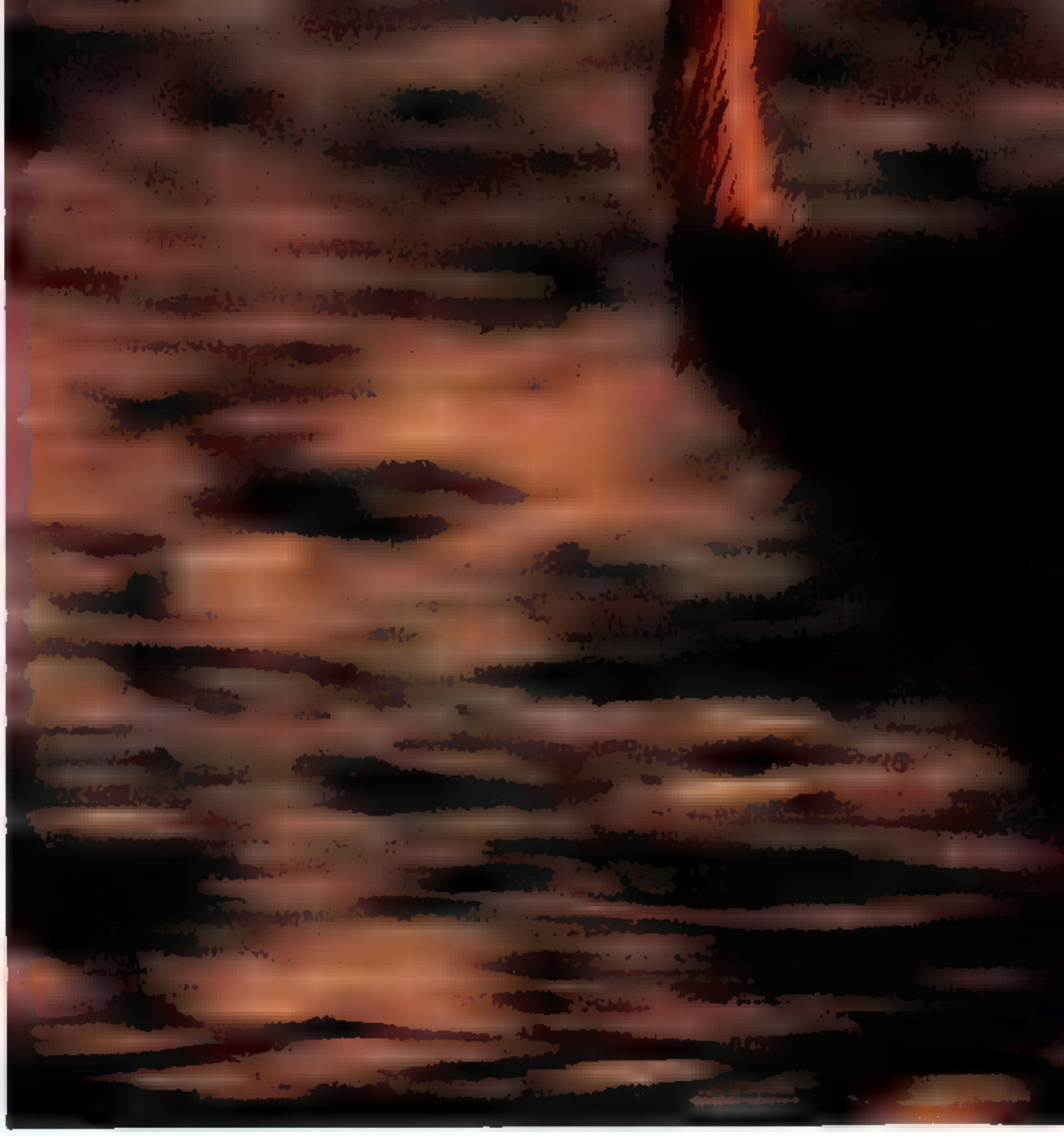
A sleepy stack of meerkat pups nap while safely tucked under a baby-sitter's arm.

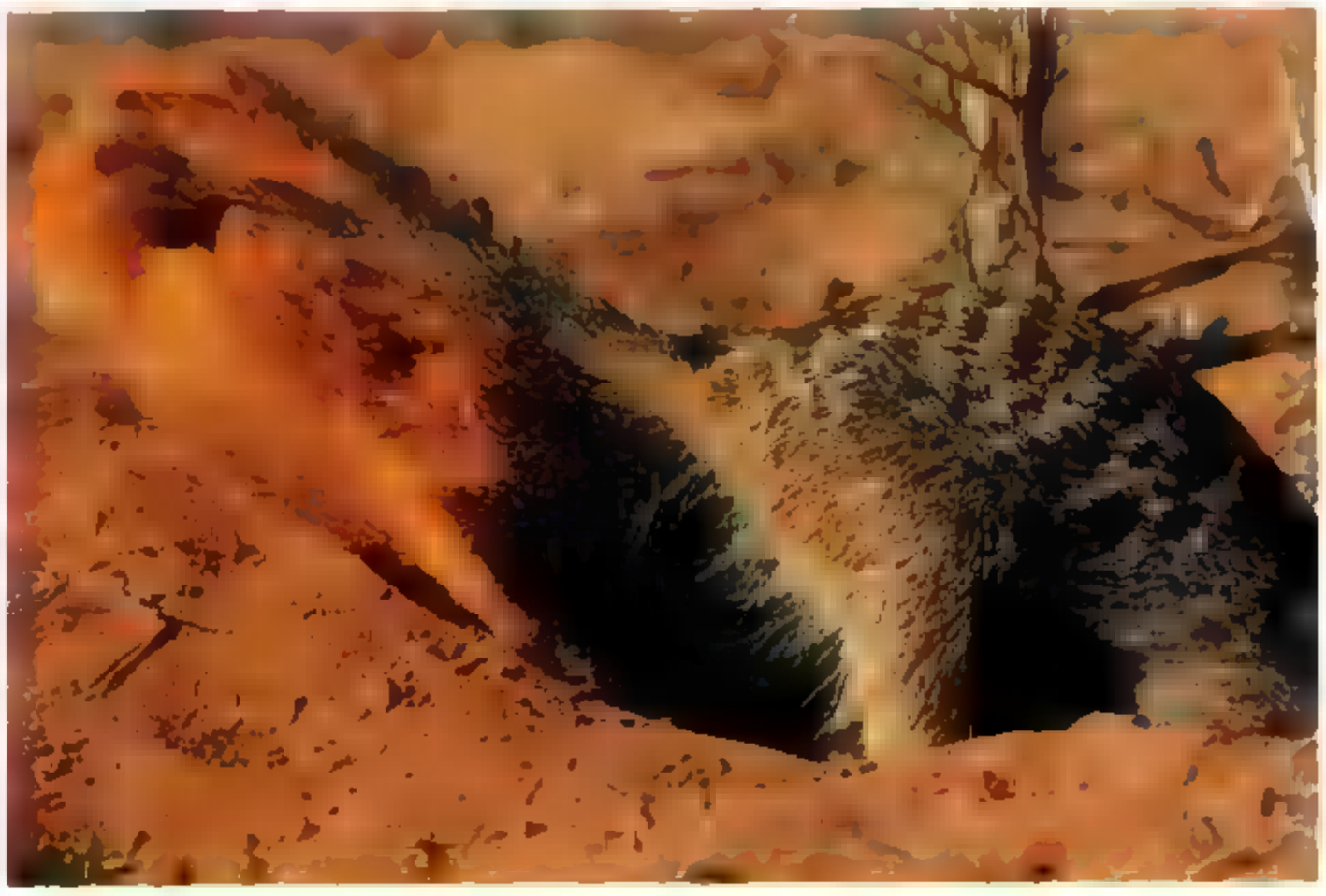
To keep up her milk supply, a meerkat mom must forage daily, and a meerkat dad must guard his mate, so other group members take turns providing day care. The service is costly for caregivers. Going all day without food, a baby-sitter can lose up to 2 percent of its body weight.

Highly placed, a sentinel keeps watch so group mates can forage without constantly

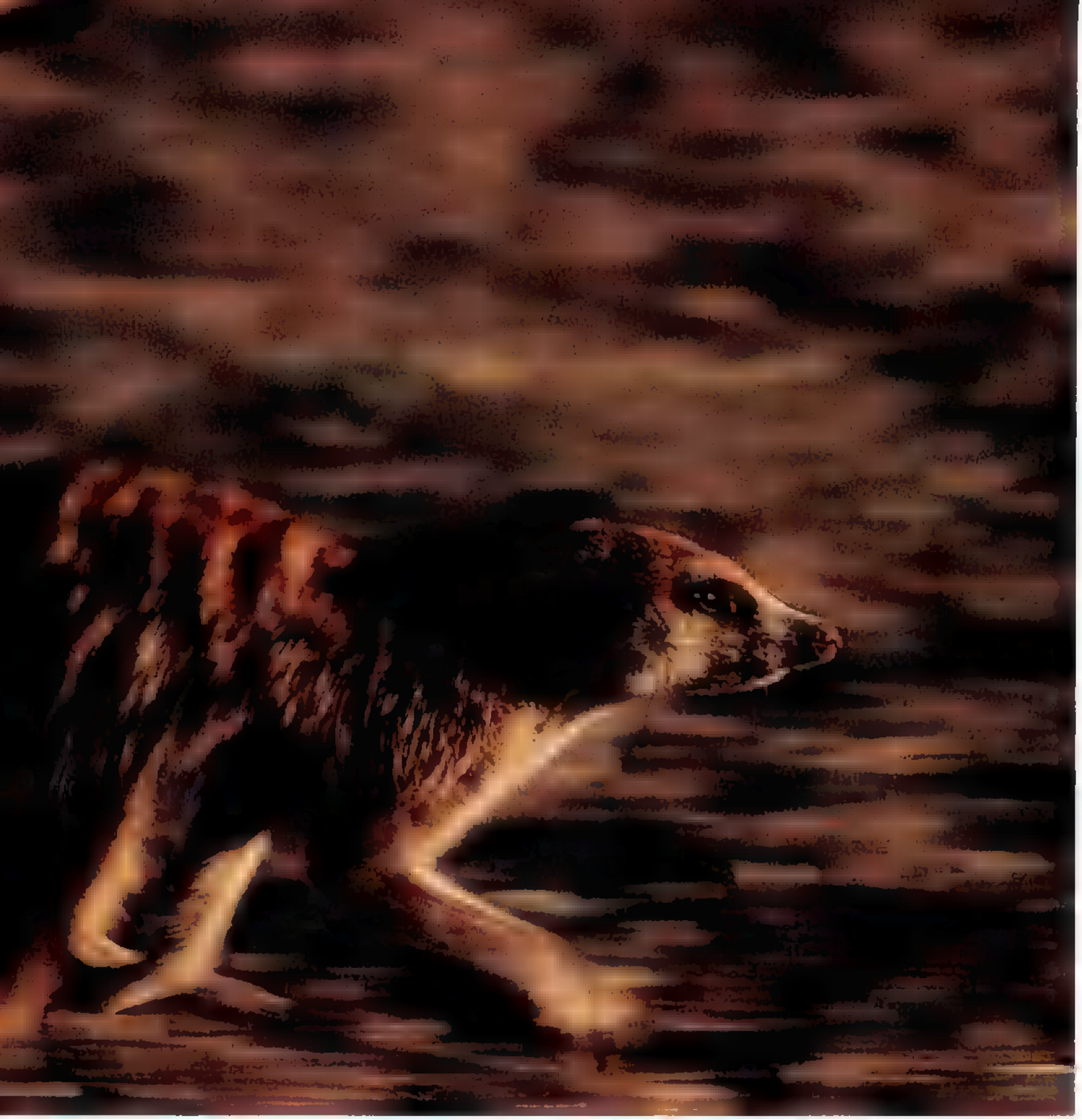
stopping to look for danger. When an eagle, cobra, or other predator threatens, the guard calls out an alarm that sends every meerkat within earshot diving for safety in nearby bolt-holes. A low, steady peeping—researchers call it the "watchman's song"—signals that all is well.

Tails up and eyes sharp, meerkats run for cover when they can and dash into battle when they must. Fighting as a single bristling, hissing mob, meerkats can scare off a predator as formidable as a 25-pound black-backed jackal. They're naturally cautious, but over time meerkats accept our team as a harmless feature of the landscape. Lured by boiled-egg treats, they'll even climb onto electronic scales to be weighed. One eager volunteer was about to crowd an already occupied tray when field-worker Adin Ross-Gillespie scooped him up by the tail (far right).



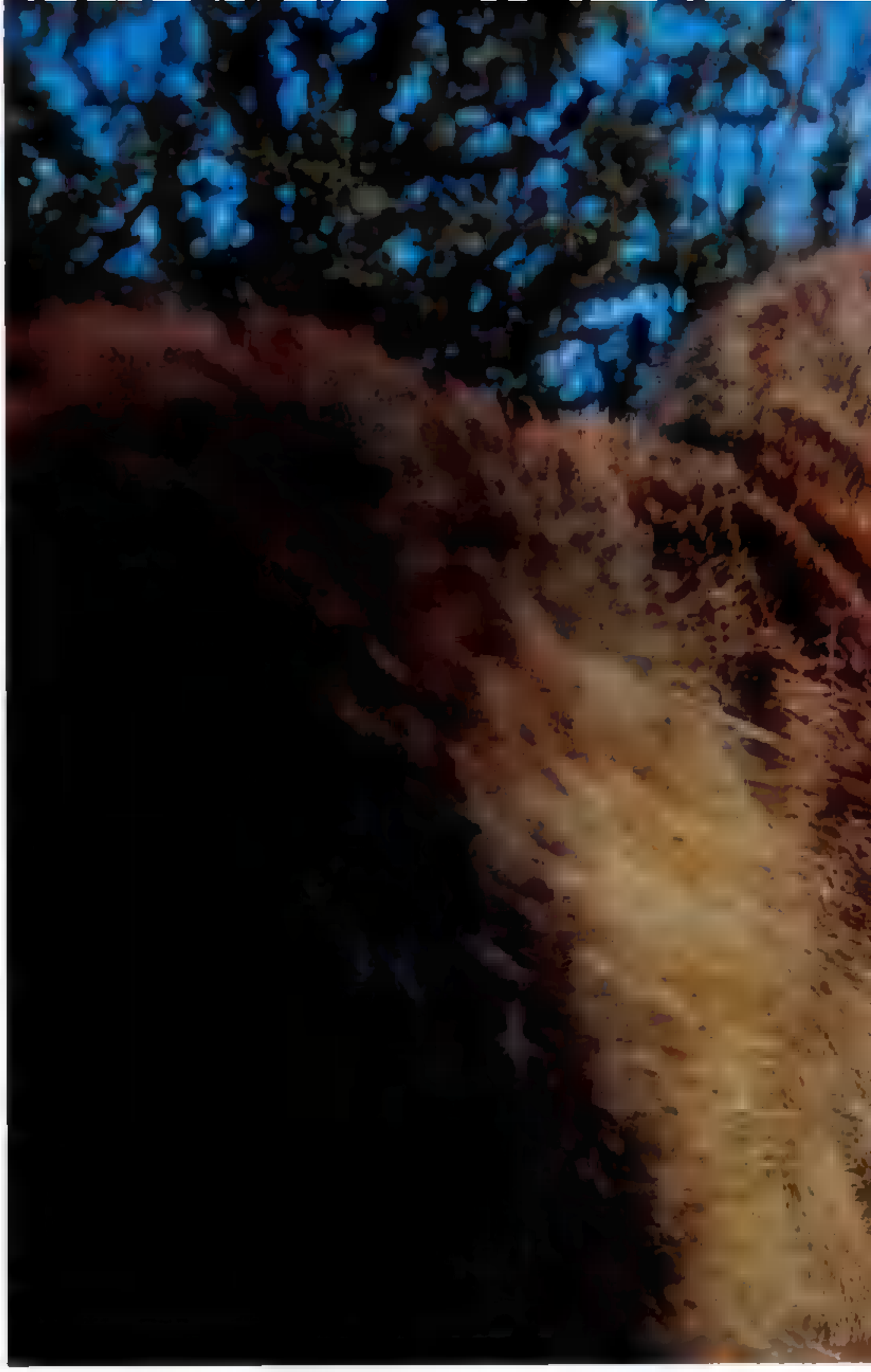


Meerkats are master excavators, with all four paws tipped by sturdy, rakelike claws. Foraging for five to eight hours every day, they frequently dig themselves entirely out of sight in pursuit of potential meals. Favorite prey include beetles, scorpions, insect larvae, and small reptiles.



Mating in the open is risky—

and rare. Outside the safety of a burrow meerkats must scan the sky for predators. Their distance vision is far more acute than ours, allowing them to spot an eagle on the wing more than a thousand feet away. But close up, other senses take over. A quick sniff (below) is the meerkat equivalent of checking ■ group membership card. Scent-marking, smelling, and grooming behaviors reinforce the relationships that help meerkats survive. Usually only the dominant male and female mate, producing 80 percent of the offspring in a group.



A fast pounce and a sharp-toothed crunch secure ■ plump, moist meal of lizard for one lucky meer-kat. Experienced hunters will share prey with pups just learning to forage, but by 3 to 4 months youngsters must be ready to feed themselves. Meerkats reach full adult size by 18 months.

A baby-sitter's embrace can

soften life's little indignities—like the ant that turned from would-be snack to lip-biting pest for a newly weaned pup (far left). Staying close means safety and comfort: With a caretaker to share body heat (left), a pup's metabolism can direct more energy to growth and weight gain. Slender-bodied meerkats lose heat easily, ■ valuable trait for adults foraging in the blistering Kalahari midday. But when desert temperatures plummet after dark, the entire group retreats to the snug security of a burrow (below) and sleeps in a single furry pile.

It's always playtime (or mealtime or nap time) for four-week-old meerkat pups.

Just old enough to begin following the grown-ups on daily foraging rounds, their future is far from certain. Burrow-flooding rainstorms, drought, and attacks by predators and rival meerkat gangs all menace the young. Even with the best care, only one pup in four survives to adulthood.

Alert to each waving
shadow, pups learn
early to copy their
elders' intense obser-
vation of sights,
smells, and sounds.
A baby-sitter's most
important responsi-
bility, even as it is pro-
tects the young from
attacks by neighbor-
ing meerkat groups
seeking to expand
their territory.

Growing from pup to patriarch

Juma's Story

IN THE SLANTING, GOLDEN LIGHT of a Kalahari evening, Juma, a young male meerkat, stares across the sandy bed of the Nossob River: nothing but the shimmer of hot air and the evening chorus of barking geckos. Six pups, their eyes only recently open, nuzzle at his stomach, hoping to find milk. Juma has been watching over them since dawn, ignoring his own hunger as he scans the sky for eagles and the ridgeline for jackals, snakes, yellow mongooses, and even neighboring meerkats, which would kill the pups if they found their burrow unguarded.

In a large meerkat group, which can have as many as 40 members, six-month-old Juma would be too young to baby-sit. But there are only five adults in his small group, so he must take his turn guarding the pups. Of the ten meerkat groups that my research team—biologists from the University of Cambridge and the University of Pretoria as well as a few students—followed during five years in what is now called Kgalagadi Transfrontier Park, we came to know Juma and his family best. We nicknamed them the Jackson Five, in honor of Tim Jackson, a resident biologist who discovered the group when it had only five members, and they quickly became accustomed to our presence, allowing us to follow them around their six-square-mile range.

Meerkats make ideal study subjects because they are only active during the day. Also, perhaps because they are prey to a large variety of birds and mammals—over half the adult meerkats in our population were killed each year—they quickly learn to recognize danger and to ignore animals that do not pose a threat. Humans, with time and patience, generally fall in the latter category, and meerkats come to accept them completely.

As we sat beside their burrows in the cold Kalahari mornings, the meerkats sheltered behind us from the keen dawn wind. When no stumps were close by, tamer individuals would sometimes climb up our backs and take their turns as sentinels from our shoulders or heads. The more they trusted us, the closer we were able to get. We collected skin and hair samples for genetic analysis, spooned up their droppings to measure their levels of sex hormones, and, using crumbs of hard-boiled egg as an incentive, trained them to climb onto electronic scales.

This long-term study, from 1993 to 1998, grew out of my belief that meerkats might offer vital insights into the evolution of mammalian cooperation. According to evolutionary logic, an individual's success is usually measured by the number of offspring it raises, but some meerkats spend part or all of their lives helping others raise young rather than breeding themselves. Such seemingly altruistic behavior can be found in very few mammals, but even within this select group, which includes mole rats, marmosets, wild dogs, and some other mongooses, meerkats are unique in the extent and coordination of their cooperative activities.

Meerkats redefine cooperation.

First encountered as a juvenile in Kgalagadi Transfrontier Park (map), a male named Juma (below) grew up to lead a large, flourishing band. Along the way he—and other meerkats like him (right)—taught us a few lessons. Evolutionary theories predict that animals will help their closest kin most. But among meerkats group loyalty rules. Sisters, cousins, and unrelated recruits alike share the group's burdens and its benefits.

Meerkats' unusual system of rearing their young poses questions that go to the roots of our understanding of cooperative societies, including our own. Why do mature offspring remain in their parents' group instead of dispersing to breed? Why do they take risks and spend time and effort to help other members breed? How do group members divide their responsibilities and coordinate their contributions? And how do they ensure that all group members pull their weight?

Few of our closest relatives, the great apes, cooperate with each other as extensively as meerkats. Human cooperation probably has an ancient history, and by studying meerkats, which depend on their group for survival, we gain a window into the evolution of cooperative societies.

OUR RESEARCH ON THESE ISSUES progressed steadily until, two years into the study, disaster struck. The irregular rainfall of the Kalahari failed completely, and the remaining grasses in the park shriveled and died. Twisters cruised up and down the riverbed, and the springbok and wildebeests left to search for the last remnants of grass in the dunes. At first the meerkats hung on, digging for beetles and scorpions in the loose sand, but gradually their condition deteriorated and they were forced to forage farther and farther from bolt-holes—quick-escape burrows scattered throughout their range—and spend more and more of their time without the protection of sentinels.

Predators quickly took their toll: The Jacksons' dominant female was the first to be killed, followed rapidly by the dominant male and by Juma's older sister—all three probably taken by one of the martial eagles that rode the morning thermals over the riverbed.

Eventually Juma was left alone with three younger sisters. For the next year these four were inseparable, a cautious group whose seamless alternation of sentinel duty ensured that no predators could get close to them. Other groups fared worse: Six of the ten groups that we had habituated were wiped out, leaving vacant ranges.

The rains returned the next spring, and the remaining groups started to breed—except for the Jacksons, all of whom were close relatives. At last, in midsummer, an unrelated male immigrated into the group, and, soon after, Juma left his sisters and his range for the first time in his life. We combed the riverbed, fearing he'd been killed, but found him two months later in a vacant range with two adult females and a related subadult male from a neighboring group.

Over the following months Juma filled out. His temporal muscles enlarged, giving him extra biting power. He put on weight and assumed the rolling gait and swagger of a dominant male. He quickly set about breeding with one of his new females, and they raised four pups successfully. Gradually the size of his group grew—from four to eight to fourteen to twenty.

TIM CLUTTON-BROCK (BOTH)

LIVING IN TENTS AND CARAVANS in our Nossob River campsite 30 miles north of Juma's range, my team and I monitored the lives of more than 200 meerkats during our five years in the park. Our immersion in the meerkats' world helped us unravel many mysteries about them, and, in turn, gave us clues to the behavior of other types of cooperative mammals. But we still struggled with one question: Why did subordinates go to such elaborate lengths to help raise others' young?

Biologists first pointed out in the 1960s that individuals that do not themselves breed can propagate their genes by helping relatives breed. An interest in advancing their relatives' survival, however, cannot be the whole story. In meerkats, as in many other cooperative breeders, all group members willingly help rear young, whether they are related to them or not.

The answer, at least for meerkats, is interdependence. Everyone benefits from living in a larger group, and everyone suffers when group size falls. No one individual can afford to spend more than an hour or two on guard each day, so small groups spend part of their time without sentinels. The larger the group, the more individuals there are to feed the pups, who grow faster and are more likely to survive. (Even nonbreeding females will lactate at the same time as breeding females.) Bigger groups are also better able to repel neighbors' attempts to take over their ranges.

Juma certainly benefited from the large size of his group. His weight increased, and he fathered six litters. Then disaster struck again. His dominant female suddenly disappeared, probably killed by an eagle or a jackal, leaving him with four mature daughters—but no female to mate with. Another group with adult females lived just south of Juma's group, and a large group with several roving males lived to the north. Juma persistently tried to lead his group south to the females, but his daughters dragged their feet and headed north toward the males whenever they got the chance. Pulled by conflicting desires, the group moved up and down the riverbed.

By this time we had our own problems. We had been working in the park for five years, and the authorities thought this should be long enough to complete the study. Eventually we were forced to pack up camp and leave.

We had followed Juma since he was a juvenile, and losing contact with him was like losing an old friend. Luckily, we had been habituating meerkats at a second study area 60 miles to the southeast on the Kuruman River. The work had been slow, but by the time we left the park we were able to observe eight groups at Kuruman, and we could recognize each individual. We simply shifted our camp and pursued our research with different individuals.

The past few years have brought good rains, and many of our Kuruman groups are now 30 animals strong. There are more group members to share the task of guarding and feeding

young, so each individual expends much less time and energy on cooperative activities. It's a far cry from the groups of four or five that we watched struggling to feed their pups in the park.

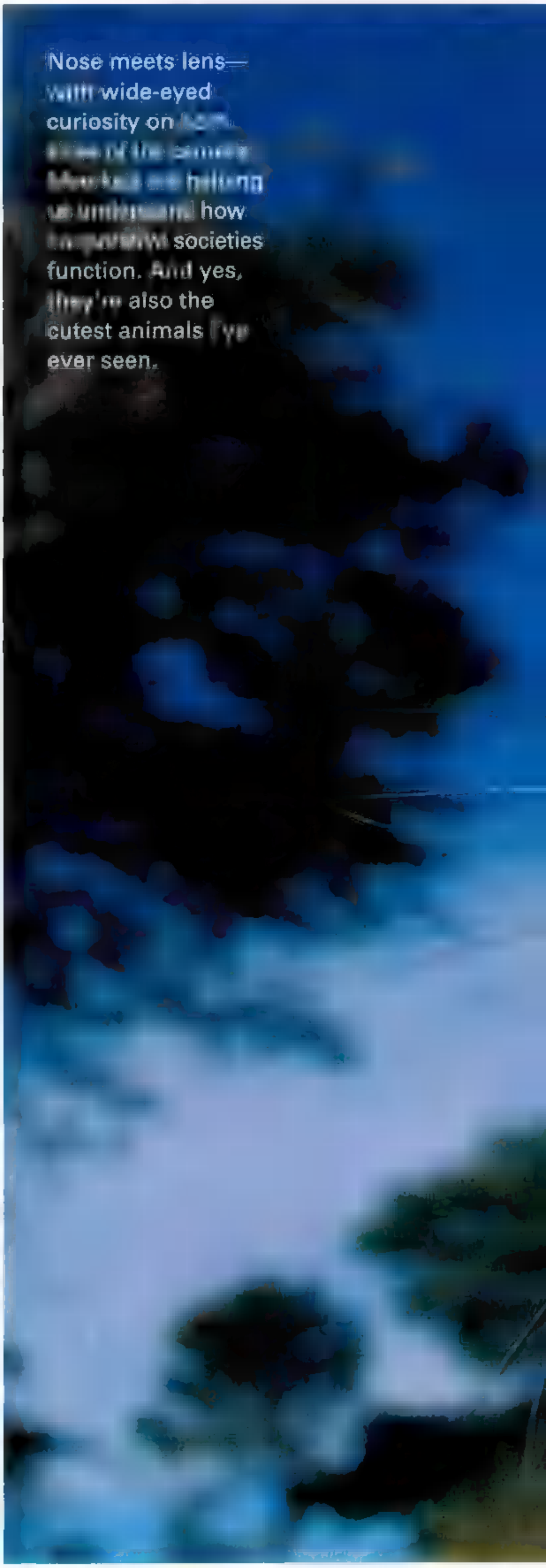
AND JUMA? LAST YEAR MY SOUTH African colleague Justin O'Riain and I were allowed to spend a week in Kgalagadi to check on the survival of the individuals we had last followed in 1998. The population had not yet recovered from the drought of 1995, and many of the ranges were still empty. The Jacksons were no more—one of their main burrows had been taken over by a family of bat-eared foxes, and the other was clogged with loose sand. We searched for two days in the area where Juma and his family were last seen, scouring the sides of the riverbed with binoculars, but with no luck.

Finally, on our last evening in the park, we saw six meerkats standing near one of Juma's old burrows. We walked slowly over to them. Five stared, barked at us, and disappeared into the burrow. One male remained, rocking from side to side, seemingly unsure whether he should follow his companions or stay behind. We sat down ten feet away. He watched as we unpacked the scales, filled the weighing tray with sand, and topped it with hard-boiled egg, just as we had once done each day. He approached hesitantly, gaining confidence with each step. A dark mark below his right eye, which in the past had always distinguished Juma from the others, was still obvious. We had found him.

Juma carefully climbed onto the scale, and we weighed him. At 28 ounces he was lighter than he had been at his peak, but he was still the dominant male of his group. He and one other male were the only survivors of the animals that we had left in the park. He was eight years old, the oldest dominant male we have known, and unlikely to live much longer. But his group was one of the largest in the area and will probably maintain its range. Eventually it will produce splinter groups, and a new generation of meerkats will fight for survival in the vast sand sea of the Kalahari. □

MORE ON OUR

Tour the world of meerkats with photographer Mattias Klum in Sights & Sounds, then find more images and resources at **nationalgeographic.com/ngm/0209**.



No trees. No telephones. No Jesus. The higher you travel into the mountains barricading the Black Sea coast of Turkey and on into Georgia's Caucasus, the less there is. In remote valleys and along steep stony tracks now forced to serve as roads, familiar components of life fall away one by one. What remains is the immensity of the sky, gaunt slopes scrubby with thistles and wild grasses, the roar of glacial torrents in dark ravines, and the powerful pull of the first gods ever feared by men. *Continued on page 80*

To the ancient Greeks these peaks marked the end of the Earth. For centuries since, the Caucasus have formed part of a mountain barrier that has separated peoples of the Black Sea from the world beyond.

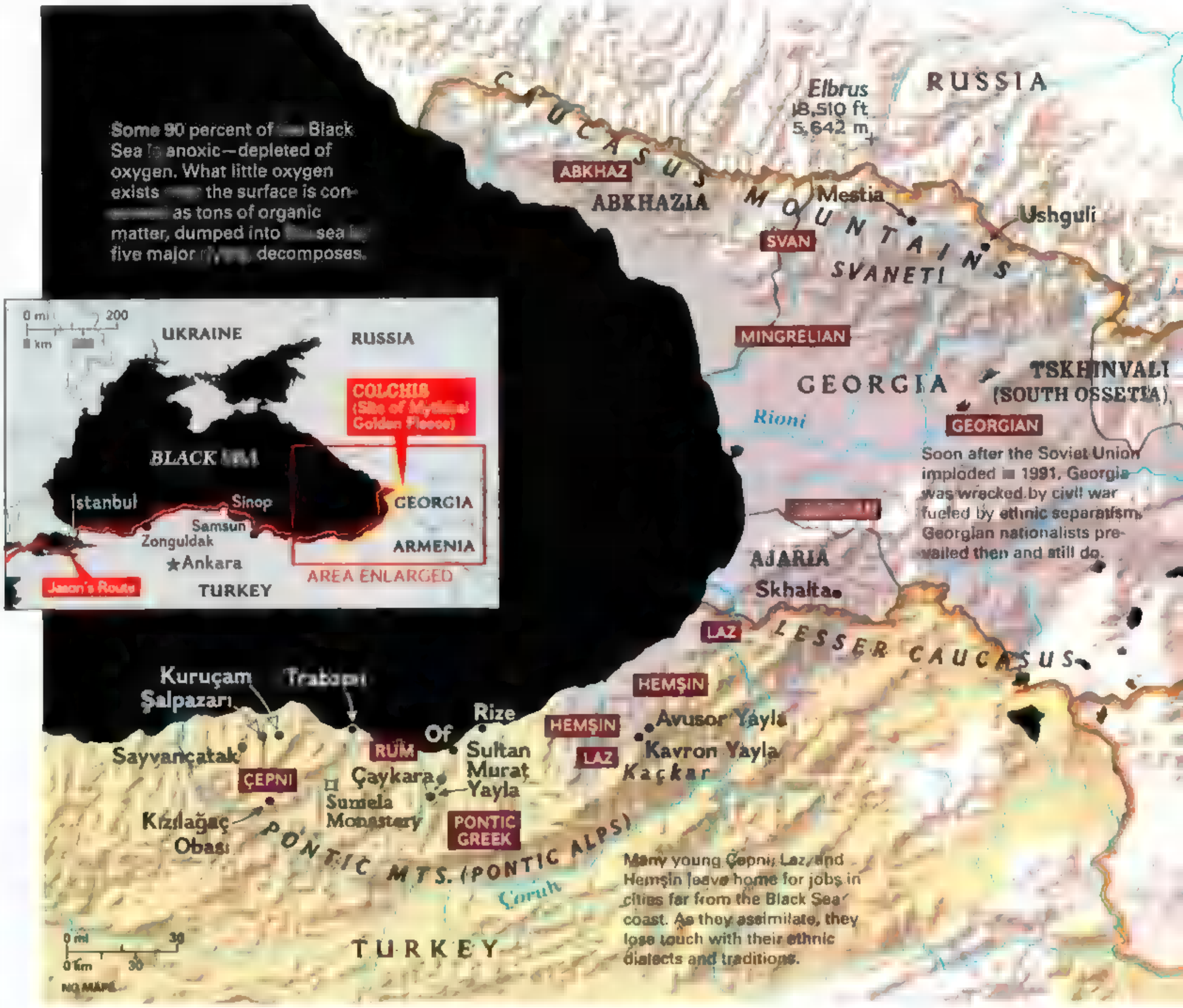
Crucible *of the* Gods

By ERLA ZWINGLE
Photographs by RANDY OLSON

[illegible] corner of the Black Sea, this is what the [illegible] wrought: a Bronze Age warrior [illegible] (above) that [illegible] never saw a moment of [illegible]. Christians who [illegible] pagan [illegible] and Muslims [illegible] Christian [illegible] communities run by clans thriving in nation-states that aspire to be modern. Contradictions? Not in a world [illegible] are [illegible] animal sacrifices [illegible] expected, and beer is a [illegible] beverage.

S[illegible] their true colors, [illegible] women near [illegible] keep one eye on tradition, as [illegible] the [illegible] other [illegible] Laz, [illegible] Khevsur, Tush. The other eye [illegible]

focuses elsewhere. "When I meet other girls in our village, we compare what's on TV with our own lives," says Özlem Tarhan, a Çepni. "But when boys arrive, the subject shifts to soccer."



In the 14th century B.C. a young Greek named Jason built a boat called the *Argo* and summoned 50 warriors to join him in a voyage from Greece to the edge of the known world: Colchis, a territory that in the past covered much of the western part of modern Georgia and stretched along the Black Sea coast from the Caucasus to Trabzon. Here a golden fleece hung on an oak tree guarded by a serpent that never slept, and the Argonauts swore to take it, one way or another, from Aeëtes, the Colchian king. What it took to fulfill this vow, the oaths and offerings and fatal magic spells, became one of the ancient world's best known myths.

Of course Jason never existed; that was why it was necessary to invent him. Anyone listening to this tale when it was finally written down in the third century B.C. recognized the deeper theme, which had nothing to do with witch-princesses or the will of the gods and everything to do with the saga of Greek settlement of the Black Sea coast. This was dangerous territory, known even today for sudden storms and notorious, at least to those who recounted the myth, for savage tribes and barbaric customs. Yet the Greeks slowly established a string of cities along Turkey's northern coast and northeastward into Colchis, the ideal connection points for trade by sea and by land.

The Greeks, though, were only part of a long and complicated history

To find the golden fleece, Jason and the Argonauts sailed from Greece in the 14th century B.C., heading east across a perilous sea toward the land of Colchis (inset map). Their mythic journey was followed centuries later by shiploads of Greek settlers who established colonies along coastal trade routes. In recent years finely tooled

gold jewelry from the fifth century B.C. (above and below) has been excavated in Georgia, a sign that the Greek myths of golden treasures were rooted in reality.

here. Early humans appeared in Georgia around 1.8 million years ago. Now, in the 21st century, the people of western Georgia mingle the customs and symbols of the cultures whence they came: pagan and Christian, Jewish and Muslim, Persian and Mesopotamian, Arab and Roman and Russian.

Only life on the narrow strip of plain along Turkey's eastern Black Sea coast, connected by land and sea with the world beyond, has kept up with the calendar, modernized along with its roads, vehicles, and general outlook. Otherwise the rugged mountain hinterland of both eastern Turkey and Georgia belongs to an unusual degree to the past. Regardless of variations in language and dress, from the Laz, Hemşin, Çepni, and Rum of Turkey to the Svan, Tush, and Khevsur in Georgia, the people share roots that strike deep into history. Theirs is still the world of sacred honor, blood sacrifice, revenge, the tending of animals, the grinding toil of women.

"Welcome to my house," said Khvicha Sisauri, a Tush shepherd, as we entered his kitchen. "Shall I kill a sheep?" Something in the way he asked hinted that there was only one right answer. "Great idea!" I said, and he went outside. Almost immediately I could hear him whetting his knife.

When company comes to the mountains of Georgia, people take it seriously. A guest is sacred, sent by God, so that as soon as you are under the roof of one person, you are protected by his entire family, down to the eighth cousin twice removed. I had been looking apprehensively at the mountains that marked the border with Chechnya, but not to worry: "The guest," Guram Kvirkvelia, my archaeologist interpreter, told me with complete seriousness, "will be the last person to die."

Guram and I, with archaeologist Giorgi Gogochuri, had reached Tusheti after laboring for hours up tortuous switchbacks and precipitous rocky ruts over a 13,000-foot pass in Khvicha's indomitable Russian-made four-wheel drive. The next day we would travel on to a village named Pharsma to join in the celebration of St. George's feast.

Though practices differ to some degree among the mountain tribes, the feast would have the essentials: the offering of sheep, beer and bread, a lavish communal meal, a horse race, and the strict exclusion of women from the sacred precincts—all customs that Jason's Argonauts would have recognized. Also, I learned, St. George would be the festival honoree in name only. Despite the fact that most Georgians are Orthodox Christians, the real divinity accepting the sacrifices would be the local spirit, called *khati*.

"Khati means icon in Old Georgian," explained Guram, whose expertise is late Bronze Age and classical Colchis. "But the khati is a pagan deity,

The winters are seven months long and bitter. The mountain roads, when open, are riddled with bandits, forcing travelers to drive a mountainous gauntlet to get there or the

medieval towers of the [illegible] settlement in the high [illegible] Georgia. Although still ruled by clans, the [illegible] cannot escape the cultural cross-fire from the world below.

This was dangerous territory, known even today for sudden storms

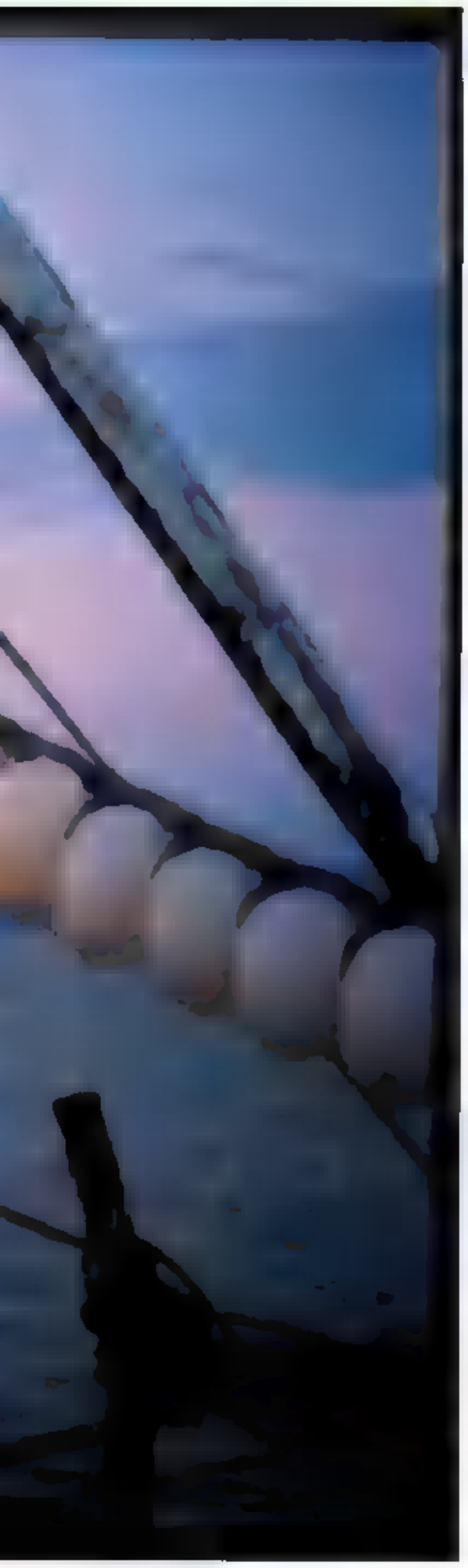
and all practices about him are pagan. The village priest is a common man, not elected and not chosen by descendant line. It's the will of the khati who becomes the priest, and the choice is revealed to the village seer."

Instead of a church each village has a stone house within a sacred area chosen by the khati. There the ritual beer and bread are made; there the sheep are sacrificed on feast days. But the khati is omnipresent all year, and not to be trifled with.

"The khati of the Khevsur can be angry sometimes," said Giorgi, referring to his own fierce people in the mountains to the west. He was sitting with us on the upper balcony at Khvicha's house in the drifting fog at twilight; from below came the sound of Khvicha hacking at our sheep. Giorgi, like many Khevsur males, had been made a "slave" of God in a boyhood ceremony when the sign of the cross was marked on his forehead with the blood of a freshly sacrificed bull. If the khati were to order him to do something, he would thereafter always be obliged to do it.

"In my memory a man built his house in the territory of the khati, and his son lost his right hand," Giorgi continued. "Everybody is sure it's the

With no golden fleece or other riches on his radar, Rıfat Pınarbaş eyes mullet, anchovies, and whatever else he can haul onto the family fishing boat. Roughly 90 percent of the Black Sea is an oxygen-depleted dead zone; pollution,



khati who took his hand. Another time a man found ■ spring and made tubes to carry the water to the khati's territory, and a lot of people in his family became sick. He went to the seer, who said the khati was angry, that if the khati had wanted the water he would have done it for himself. So now additional sacrifice would be required from the man and also from his descendants. If anybody cuts the trees or shoots a gun in the khati's territory, same thing. No excuses."

The khati's cult is a fantastic mixture of pagan and Christian elements, from the fact that each village spirit is given a saint's name to the ceremonial readings from the Old and New Testaments. The people of the Caucasus have no difficulty reconciling these contradictions. "If you tell a Khevsur he's a pagan," Guram commented, "he'll kill you. He sincerely believes he's a Christian."

THE NEXT MORNING we left early for the festival, crossing and recrossing a racing icy river gray as liquid clay, past stony villages guarded by stonier towers. The sun welled up over the mountaintops and spilled over their peaks. In steep fields men were already out, scything as much wild grass as they could in the short summer. After almost three hours we reached the Tush village of Pharsma; the sacrifices were well under way.

The sacred area was atop a rise just behind the village, a wide green swath surrounding a dark stone building. Guram and Giorgi continued on without me to drink the proffered glass of sacred beer and join in the sacrificing. Being a woman, I was forbidden to come any closer than 150 feet, but I could see a long pole protruding from the stone wall that surrounded the building; it was hung with brightly colored cloths, the khati's banner, with a bell on the end. These pieces of new fabric recall the adornments that in past centuries were draped on the horns of sacrificial bulls.

Within the confines of the sacred area, the sacrifice of sheep progressed. Each time an animal was presented, the priests shouted a

and notorious . . . for savage tribes and barbaric customs.

overfishing, and alien species threaten to drastically degrade what remains. "The catch varies a lot year to year, but we still get enough," says Rifat. Or, as locals like to say: "God looks after the poor by providing fish."

short, chanting prayer—"May this man's family be protected"—and then jangled the bell. The man offering the sheep would then kill and butcher it on the spot. The shouting and the bell ringing went on past noon. It was going to be some feast.

From where I stood, I couldn't see the sacrifices, but I could see the assortment of bloody fleeces hanging on the stone wall. Not golden, like Jason's fleece, but still clearly linked to the sacred. These would be the prizes for the riders in the afternoon's horse race.

A number of traditions linked to gold may have interlaced to form the myth of the golden fleece. The people of Georgia's Svaneti region joined the cult of the sun with that of the ram in the sixth century B.C. Some 19th-century accounts describe local people laying fleeces in streams to capture bits of gold, a practice that may well date back to ancient times.

As activities in the sacred area continued, I wandered through Pharsma and came upon other touchstones from Jason the Argonaut's time: the honor in vendetta, the honor in sacrifice. I paused to talk with an old, wiry man with a darkly sunburned face. He'd been born in the village, and he was willing to talk about his life.

Today the sea—now more distant culturally than physically from the

"When I was two or three," he recalled, "my uncle was killed by some Kist," a Muslim ethnic group scattered through the Caucasus. "My father killed 37 Kist in revenge. Not in one day but over the years. It was his personal obligation to kill them. He had promised to kill 40, but he died, that's why he didn't kill the last three. Then the Kist came and said I had to repay my father's actions with 30 sheep and one house with all the furniture in it, but I said no. Since my grandmother was Kist, I had some supporters among them. Then time passed and everything became quiet."

We were leaning back against a low stone building under the scorching midday sun. Occasionally there was the distant chanting shout and bell ringing of another sacrifice; twice a helicopter flew low and fast over the village and up the valley, European observers patrolling the Chechen border for guerrilla movements.

A bright-eyed boy had been watching me curiously. I asked him his name. "Amirani," he replied. In one of Georgia's most famous myths, Amirani was the hero who challenged God and in punishment was chained to Mount Kazbek forever. When the Greeks, who could see the gleaming Caucasus summits from out at sea, heard this story, they amalgamated it with their own myth of Prometheus, moving him from his previously anonymous mountain peak to the Caucasus as well.

"I have a heifer," Amirani volunteered. "I call her Marta. The first calf she had was a bull, but we sold it. The firstborn always has to be sold or killed, you can't keep it." Firstfruits offerings have traditionally been the most sacred in many parts of the world, and all the families at today's gathering had brought, if not a sheep, certainly a bottle of the first distillation of *tchacha* and specially baked bread.

By the time I had walked back up the hill behind the village, the best

Their mining tools are pick-and-shovel simple, with yields correspondingly spare. Yet these coal miners in Zonguldak, Turkey, have at least one reason to smile: They have jobs. State officials periodically consider closing these financial black holes, but when faced with the widespread social trauma the layoffs would inflict, they keep the mines open. Jutting strategically into the Black Sea,

mountain villages—still exerts a sort of tidal pull of possibility.

Sinop (above) was once a prosperous port, flourishing because the region's roads were either abysmal or nonexistent. Since the 1930s, though, the roads have gradually improved, with a major coastal highway now under construction. With more goods moving by land, Sinop bustles less these days.

parts of each sheep, including the liver, had been dedicated to the khati—as the ancient Greeks would have dedicated them to their gods. The meat, which the villagers only rarely indulge in, was boiling and roasting, and by midafternoon some 500 men, women, and children were sitting on the ground facing each other across long strips of oilcloth covered with dishes of meat, cucumbers and tomatoes, stewed eggplants, hot green peppers with wild herbs, and slabs of white cheese.

The horse race began at six. We all crowded the cliff top overlooking the river, watching the eight small, sinewy stallions typical of the Caucasus thunder along the riverside, slowly stretching out in a line. Then they were clambering up the steep, slick, rocky path to the village. Gasping and blowing, the horses struggled up the last stretch, well strung out, some of them balking.

Because Pharsma is inhabited only in the summer now, the feast day is a great annual homecoming. The party would last long into the night, friends and neighboring villagers eating and celebrating, passing along plastic pitchers of brown, opaque beer or dark, amber-colored wine.

WINE IS THE SOUL OF GEORGIA, and the toast is the soul of the wine. Not for Georgians the random, inarticulate good humor of the glass in hand of most Westerners. The head of the table is the *tamada*, and he directs the sequence of toasts in a formal manner not unlike a priest: the first to God Almighty, then to the archangel Michael, St. George, and to ancestors. These invocations focus the mind and still the spirit, sanctifying even the simplest meal.

My last evening before leaving Tusheti, I sat *(Continued on page 92)*

Every spring Tahsin Erdem leads his [illegible] to greener [illegible] in [illegible], well above the timberline. Other [illegible] lowlanders join him on the yayla *[illegible] a*

summertime move to the mountains made by those who yearn to breathe fresh air, to relax with family and friends, and to reconnect with the ways of their ancestors.

Spending the warm months in the mountains keeps tradition alive—but why rough it beyond what's necessary? In Avusor, Turkey, Adem Kesimal (above, at left) hooked up a small generator, powered by snowmelt, to give each home enough electricity for a few lightbulbs and a radio. "A change for the better," he says. In Sayvançatak, electricity arrived in 1982, when the Yanik family bought the village's first television set—which is still working, alongside their butter churn (below).

Making hay near Şalpazarı, the Tarhan family are Çepni (below), whose modest size as an ethnic group means they pose no threat to Turkey's political unity. Other groups have been less fortunate: In the 1920s Turkey sent almost a million of its Greek Orthodox citizens to Greece; the Greek government transferred its Muslim nationals to Turkey. Pontic Greeks in Sultan Murat Yayla (above) are a few of the remnants—those who stayed put because they converted to Islam.

She had no more tears. A kind of abyss stood between the

(Continued from page 87)

in a birch grove for a twilight picnic with Khvicha and Ia, his wife. Rostom and Maya, his brother and his sister, joined us. As we gnawed the last of our meat on skewers hot from the fire, Maya took out her little accordion and began to sing. Tush music is quivering music, like the birch leaves, the light in the grasses, rapids in the river, distant echoes, the silence. As the last light was gleaming from the peaks, Khvicha raised his glass.

"To disappeared Tush, who died without descendants and whose houses have been taken over by plants, to their memory.

"To all the young people who miss this village, who can't be here now.

"To the past times that will never return to us.

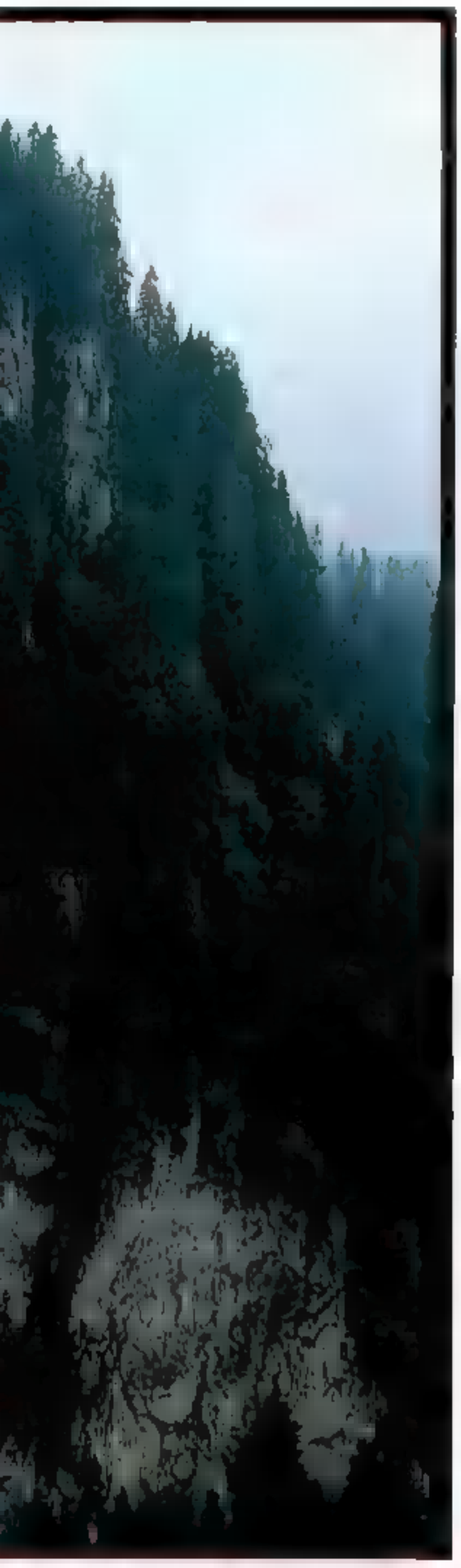
"To sisters and brothers. To Erla's two sisters. To Ia's sister."

For Guram, an only child: "To those who are to you as a brother and a sister."

Jason the Argonaut would have dedicated the wine and the words only to the gods; here the phrases also included us.

I came upon a toast of an altogether different sort at a funeral in the Georgian region of Svaneti west of Tusheti. A widow, no longer young

Clinging to the hills near Trabzon, Turkey, Sumela Monastery began as a sacred grotto in the fourth century and grew to its current size by the 14th, just before the Ottoman Turks conquered this region and the rest of the Byzantine Empire. The monastery was abandoned in the



but not yet old, sat swathed in black in the shade of the trees, wailing at the feet of her just buried husband. At the head of the grave was a small table with a large glass jar full of pale wine and a few small glasses. When a mourner approached—always a man, I noticed—he would take the jar and fill a glass. But rather than drink, he would silently pour the wine in a short line onto the bare earth of the new grave.

She had no more tears, but now the wine moistened and softened the soil. A kind of abyss stood between the silent villagers and the woman's exhausted, hopeless lament. No consolations of Christianity here; the local priest was absent. "We believe that on this day even God himself is mourning," one man explained. But which god was accepting this libation? For me, the question lingered.

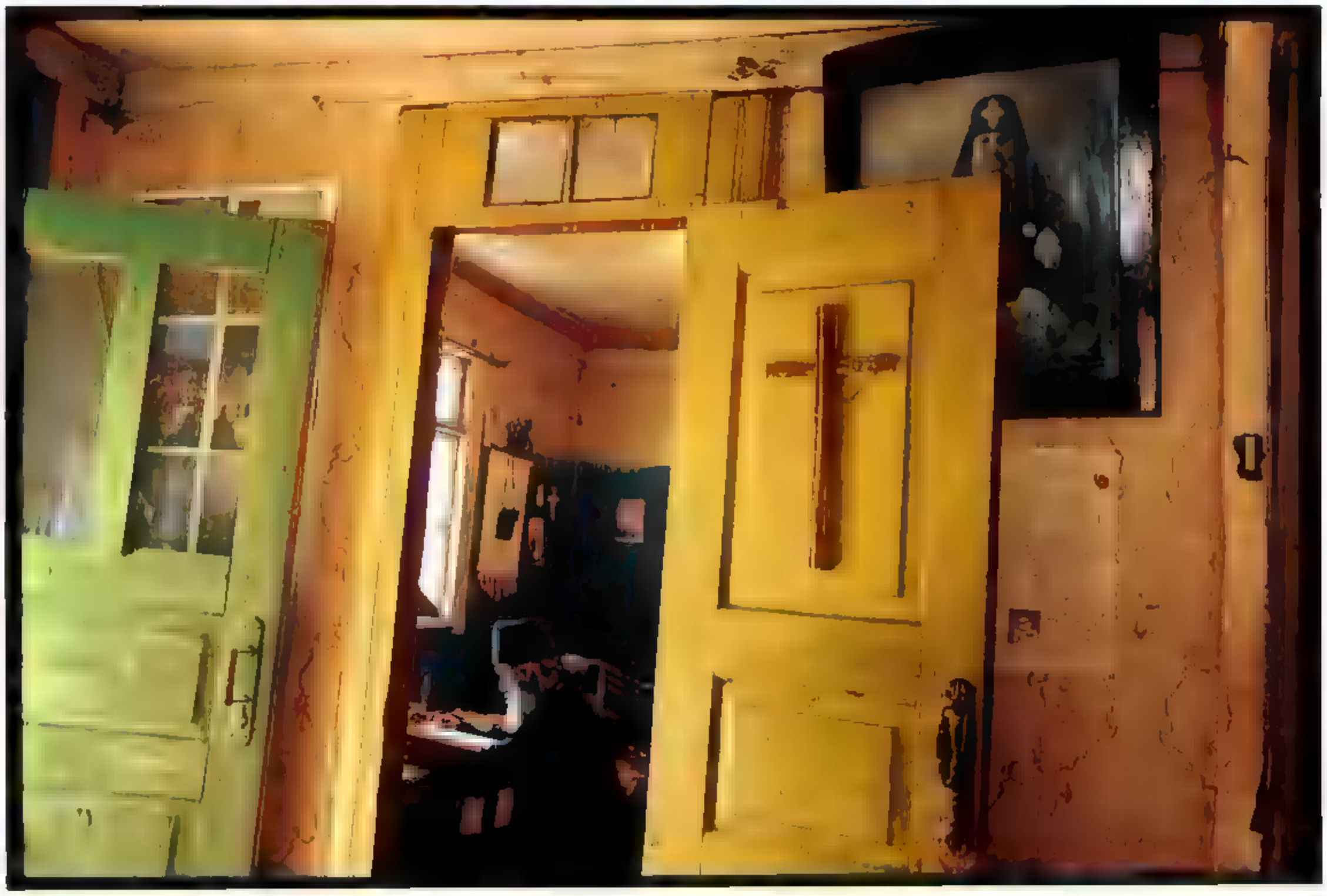
The most solemn toast of all I witnessed one evening in Svaneti at dinner. The tamada lifted his glass: "To Michael Khergiani," he intoned, referring to the Svan alpinist "tiger of the rocks," killed years ago in a fall. The men all silently got to their feet, glasses raised. When it was time to drink, Guram tore off a piece of bread and delicately poured wine onto the bread. But he didn't eat it. He placed it on the edge of his plate, where it rested, soft and moist, like earth.

"TO PEOPLE IN THE WESTERN PART OF TURKEY, everybody east of Samsun is Laz," said Aydın Kudu, my interpreter. What this shows, apart from a little misinformation, is the fascination that the people of Turkey's Black Sea region exert on their countrymen. Some 200,000 Laz embody the ancient link between Georgia and Turkey, when the area now divided by their common border was known as the Kingdom of Lazica, or later, under the Ottoman Empire, as Lazistan.

The Laz are famous for being fiercely independent ("Only a Laz woman can handle a Laz man," they say), quick to laugh, especially at their own expense, addicted to hawking and to carrying pistols, and they often work in construction or other building trades. But the Laz are not

silent villagers and the woman's exhausted, hopeless lament.

1920s, and later vandalized. Now the government is restoring this bastion of the Christian faith once ascendant here. Observing the rites of Turkey's dominant religion, Muslims mourn at a funeral in Kuruçam (right).



Theirs is still the world of sacred honor, blood sacrifice, revenge,

this eastern region's only distinctive people. Three smaller groups, the Hemşin, Rum, and Çepni, live in parallel ranges running close together near the coast, the soaring Kaçkar mountains and the Pontic Alps, named after Pontus Euxinos, Greek for Black Sea.

While the Laz and Hemşin spring from eastern roots in Georgia and Armenia, another group, called the Rum, is the sole remnant of the medieval west: Greek Byzantium. When Constantinople fell to the Ottoman Turks in 1453, most of the Greek Christians who remained in the Black Sea area gradually converted to Islam. The Rum are their descendants, and although they are Muslim Turks, their private, unwritten language, Rumca, is a form of Greek.

The Black Sea people of Turkey share foggy, jungly mountains that have the highest rainfall in the country, a passion for dancing and music, and seemingly infinite self-sufficiency. (In Turkey it's enough to say you're from the Black Sea for everyone to assume you're a genius of resourcefulness and skill.) The mountains press against the coastline, in some places plunging straight into the sea, leaving only strips and pockets of space for towns and roads. Villagers have always traveled back and forth between the shore and the peaks, and for centuries several important caravan routes through the mountain passes linked Trabzon to the luxurious cities of Persia and even India. Today the sea—now more distant culturally than physically from the mountain villages—still exerts a sort of tidal pull of possibility. The coast has always meant trade, travel, and prosperity.

Despite shared geography, the Black Sea people maintain their differences. A well-worn joke tells of a homesick Laz in Germany, who, seeing a car bearing a Turkish license plate with the prefix 53 (identifying the

On April 19, 1989, a landslide near the Georgian village of Skhalta killed 21 people—but not those who sought refuge at a nearby 13th-century Orthodox church (above). Two years later the Soviet Union collapsed too, thereby liberating Georgia and freeing Christians to resurrect their faith. More than 20 churches in the area have been built or

the tending of animals, the grinding toil of women.

reopened since 1989. Across the Turkish border in Trabzon last year, the local municipality offered free circumcisions for young boys. In one day families ushered more than a hundred children through this Muslim rite of passage, including six-year-old Mustafa Özsoy (above). Says Mustafa's father, "I tried to convince him that it wouldn't hurt."

car as coming from Rize, the unofficial capital of the Laz), kneels down to unscrew a tire's air valve so he can breathe some hometown air.

The Hemşin are concentrated farther east, up in the mountains beyond Rize. Though traditional costume is becoming less common, many Hemşin women in the villages there still wear *posi*, a two-piece headdress comprising a filmy square anchored by a twisted and knotted strip of fabric. Çepni women, on the other hand, favor a colorful costume that entails bloomers, a pleated dress, and a piece of heavy woolen cloth tied firmly around the hips with cords ending in tassels. The Hemşin are known throughout Turkey as pastry cooks, for the way they don't roll their *r*'s when they speak, and for being ardent devotees of the *horon* —a line dance for both men and women that can go on for hours to the whine of the *tulum*, or bagpipe, along with the curious throaty cry the dancers spontaneously shout together. The Laz favor a small three-stringed violin called *kemençe*, while the Rum often play a shepherd's pipe called *kaval*.

ALTHOUGH CUSTOMS OF THE BLACK SEA PEOPLE are visible everywhere in this tiny corner of Turkey, many more have dissolved in the vast sea known as modern life. Still here the people are determined to keep what they can. First on everyone's list would be the *yayla*.

The yayla is the common summer pasture high in the mountains. These also exist in Georgia, but to a lesser extent, and without inspiring the deep, atavistic hunger that the Turks feel for these empty, unspoiled spaces. Every spring for countless centuries families who have wintered in lowland settlements have herded their cows slowly up the rocky paths

to these hamlets above the timberline. In the Kaçkar range, under black heights scarred with snow and glinting peaks gashed by knives of falling water, they spend the summer living in small huts they may have owned for generations, milking the cows and making cheese and butter for the winter. The cows wander at will, and the children run wild.

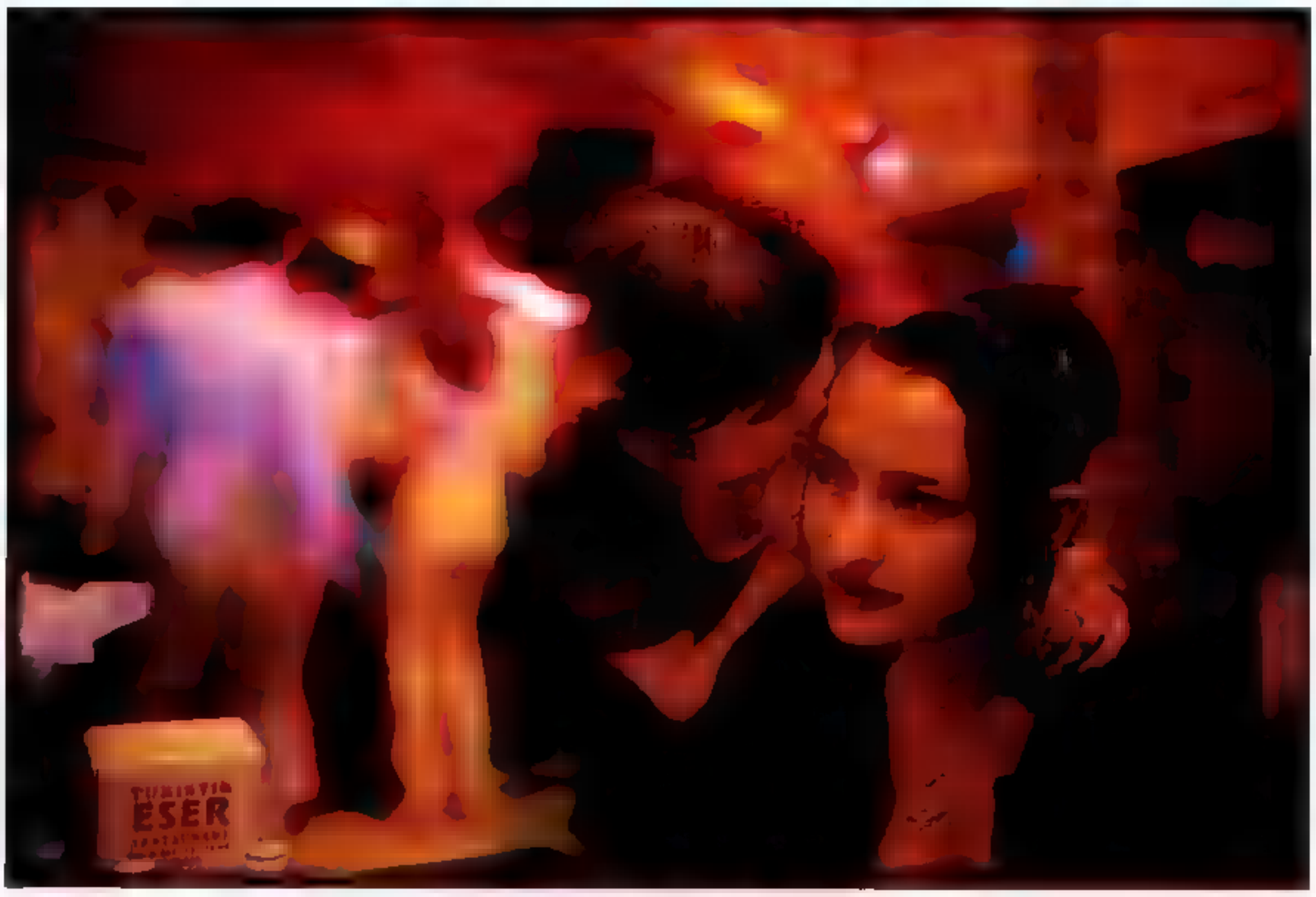
Depending on the area and the people, the houses may be anything from small and stony to modest chalets of dark chestnut; the terrain may be steep and rocky or sweeping meadow; the cows may be fewer these days and may even arrive by truck rather than on the hoof.

But for the families the experience is still the same: returning to nature, living as their ancestors did, essentially camping out. The expression "a house like a yayla" connotes almost everything good—horizons, space, peace. "If you put my husband in a five-star hotel in Ankara," one Çepni woman told me, "he wouldn't be as happy as he is up here, with almost no water." The earliest Black Sea peoples worshiped nature, and the people today still do.

Aydın drove his Subaru SUV from a coastal town named Of up into the mountains, jostling over rocks and potholes, past wooden farmhouses

Its engine sputtering near the Rioni River, a 20-year-old Soviet-made car works no better than the republic of Georgia, where 60 percent of the people live in poverty. Some desperate folks pack up whatever they can carry—even pipes and wiring ripped out of homes—to sell at

"Welcome to my house," said Khvicha Sisauri, a Tush



flea markets across the border in Turkey. In Trabzon, prostitutes from the former Soviet Union sell themselves (right). Called Natashas by Turks, such prostitutes have entered the growing underground economy that thrives along the Black Sea coastal route to Istanbul.

shepherd, as we entered his kitchen. "Shall I kill a sheep?"

and swatches of cornfields and the odd tobacco patch clinging to a steep, green hillside. It could have been a scene from deepest Kentucky, if not for the occasional minaret punctuating the lush forests and tea gardens, or the women scything the slanting fields of hay. We eventually reached a vast, airy moor dotted with houses that undulated toward the horizon, wherever that might have been in the soft folds of the fog. We reached the yayla of Sultan Murat, whose main street was lined with fruit and vegetable shops. We stopped in front of one, and Hüseyin came out.

Small and compact, with blunt, hard hands and short, light brown hair, Hüseyin is a Rum. He has a square, lined face, brilliant eyes, and a taut energy that strains at the reins of good manners. Hüseyin remembered Aydın from an earlier visit, and before long we were down the path and sitting inside his house with his family and their friends, drinking tea. He and Aydın lounged on a broad mattress on the floor of the small living room, while I squeezed onto the only bench with two of his daughters, Elif and Tuğba. Ayşe, his ample, red-cheeked wife, sat on the floor cross-legged, leaning against the wall facing us.

"I like the way of life here," Hüseyin was saying. In the winter the family live near Çaykara, the town halfway down the mountains, but they always bring their two cows here for the summer. "In town you lose all your energy—here you gain energy."

Ayşe agreed. "Cooking and cleaning and milking cows don't make you tired if you have peace of mind," she said, "and here we have a lot."

Filmy fog floated in through the open door across her face, mingling with the gray smoke from the fire in the small iron stove in the corner. One Turkish writer nostalgically recalled the yayla smell: Fog, wood smoke, cow dung. In fact, it was time to bring in the cows.

They both followed Ayşe placidly into the stalls under the room where we'd been sitting. I sat with her while she milked them, breathing in the hay smell, slightly mesmerized by the wind chime tones of the bells around their necks. It did seem more than a little idyllic here, but of course I didn't have to lug the heavy can of fresh milk upstairs or do

Women are forbidden to perform ritual animal sacrifice in Khevsureti, but the local khati, *or deity, permits them to wash their hands in the blood. In the Caucasus the cult of nature*

long been a powerful presence, competing with pagan kings eager to baptize their subjects and with Soviet apparatchiks anxious to stamp out such subversive pagan rites.

Beer guzzled from the horn of a mountain goat, men belching on a hilltop, ritual animal sacrifices—a summer feast in Georgia's Tusheti mountains might at first seem to be a heathen bash. Yet these men go to church, baptize their children, and consider themselves Orthodox Christians. In Svaneti

Although customs of the Black Sea people are visible everywhere,

anything with it afterward. Talk about doing something the traditional way, and you're talking about somebody who is sweating.

The Black Sea Turks acknowledge that the yayla tradition has begun to change. It's not just that more people are using concrete rather than wood for their houses. More family members are living in cities, so there are fewer cows to tend and less time available to spend with them in the mountains during the summer. Members of the younger generation have more money than their parents did, so they go to the Aegean beaches or even abroad for vacation instead of going to the yayla.

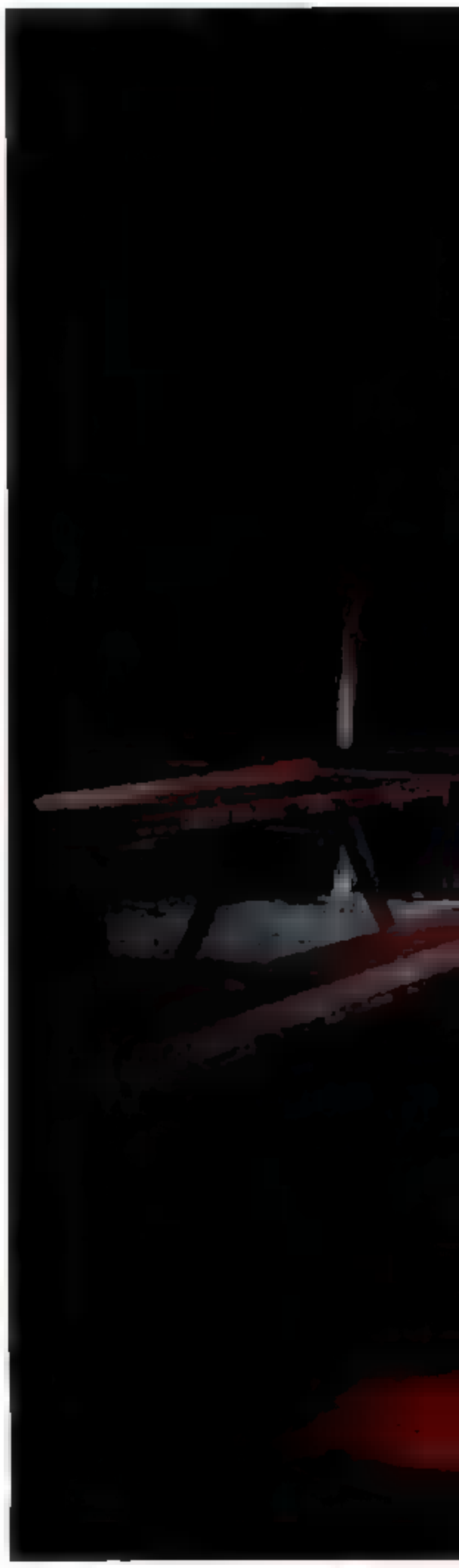
"I want my computer, I want my TV, I want my friends," said Yiğit, a young Hemşin man in the yayla of Kavron. "There aren't many people my age here. They're old people or little children."

Even the older generation sees that change is inevitable. "It used to be all you needed to buy was kerosene and sometimes tea and white flour during Ramadan," said Şefik, a Çepni father. "I can live like that, but not my children. What once determined if a man was rich was if he had enough corn to feed his family. Now what determines if a man is rich is a flat in the city, a good salary, a car."

Perhaps it is the very youngest who will turn out to keep the yayla tradition alive. Gizem, Şefik's nine-year-old cousin, told me the yayla made her feel free. "In Istanbul, when we want to go somewhere, my mother doesn't let me go alone. There are cars, traffic. Here I can go everywhere when I want."

"I just like it here. It's entertaining, time goes fast," said Pakize, a 14-year-old Hemşin girl.

Jason coasted the Black Sea's rocky shoreline, where vacationing families now float in big inner tubes, becalmed argonauts fighting the heat. The mountains and forests for him were full of danger, known only by their terrifying tribes and their even more implacable gods, of whom today's khati is a relatively benign survivor.



MORE ON OUR WEBSITE

Hear more tales of the Black Sea peoples ■ photographer Randy Olson reads excerpts from his journal ■ **nationalgeographic.com/ngm/0209.**

What is the bond that links the Black Sea people of Georgia and Turkey to their past, to each other, and to their future? "The primitive belief in the forces of nature," mused Shota Chartolani, an archaeologist I'd met in the mountains of Svaneti. "I think this was the main force that helped these tribes to survive."

a small home (below) that once sheltered more than 40 people is now the venue where clan leader Biba Marghiani helps settle disputes.

What is the survival secret of groups like the Svan: geographic isolation? traditions? fate? Says one local expert: "Svan don't usually question such things."

The forces of nature are still the source of their strength. I had seen it in the easy rhythm of summer days high in the mountain meadows, in the boys riding the stallions bareback up and down the rocky slopes. I had felt it in the ecstatic music of a black-haired Laz man playing his kemençe in a dripping, darkening forest; in the propitiations of blood or wine that mark every important passage from the building of a boat in Turkey to the departure of a guest in Georgia; in the way the Hemşin dance the horon for pulsing, hypnotic hours, perhaps no longer remembering that its slow-moving circle connects them to the frenzied bacchic dances of earliest Greece.

The people of the Black Sea have indeed survived by honoring the forces of nature. But do they even think about how deeply their lives have been shaped by them? They have no need to. They belong to them. □

many more have dissolved in the vast sea known as modern life.

The state of the Black Bloc

Each day the global population grows by 219,000 people. *Population Reference Bureau*

Ten years ago representatives from more than 178 nations gathered in Rio de Janeiro to plan how to protect the world's resources. From this Earth Summit came pledges to safeguard ecosystems, reduce global-warming gases, and promote human welfare through sustainable development. World leaders, scientists, and activists are now meeting in Johannesburg for another Earth Summit, the so-called Rio+10. On the agenda: a reality check on if and how Rio changed the world.

By Michael Klesius
NATIONAL GEOGRAPHIC WRITER

HINDU FESTIVAL IN KERALA, INDIA. STEVE

7 Scientists take stock of the planet's health a decade after Rio. Is the condition serious? A look at Earth's vital signs.

The global average temperature in January 2002 was the highest on record for that month: 54.9°F. *NOAA*

E. O. Wilson
sociobiologist, Harvard University

An influential scholar on evolution and **biodiversity,** Wilson believes that since Rio there has been a dramatic increase in our awareness of the planet's health. "But the juggernaut of habitat destruction doesn't appear to have slowed significantly," he says. "I feel encouraged by our scientific knowledge and discouraged by the destruction of the principal reservoirs of biodiversity."

Jane Lubchenco
marine ecologist, Oregon State University

"I think it's fair to say that oceans are the Jenny-come-lately issue in the environmental field," says Lubchenco, who studies the fragility of **marine ecosystems.** "Most people think of oceans as so immense and bountiful that it's difficult to imagine any significant impact from human activity. Now we've begun to recognize how much of an impact we do have."

Sherry Rowland
atmospheric chemist, University of California, Irvine

An authority on methane and other gases that trap heat in the atmosphere, Rowland thinks our understanding of the **chemistry of the atmosphere** has improved much in the past decade. He cites the public's familiarity with the greenhouse effect and how the gases emitted from power plants and cars contribute to global warming. "But in terms of changing our behavior, the word 'Rio' went to sleep for ten years," Rowland says. "It's alarming to see our rising use of fossil fuels despite evidence that they are heating the planet."

Wes Jackson
crop geneticist, The Land Institute

Jackson has long warned that annual plowing causes two billion tons of U.S. topsoil to erode into rivers and eventually into the Gulf of Mexico, where soil and fertilizers leave a **dead zone.** "At the institute we're developing [redacted] agriculture based on natural ecosystems," he says, citing research on perennial plants whose roots stay put year after year to anchor the topsoil. "We need to build an agriculture as sustainable as the nature we destroy."

Richard Barber
oceanographer, Duke University

"There is no part of the **ocean** not feeling the heavy hand of society," says Barber. "The documentation needed to show that the oceans were warming up because of greenhouse gases didn't exist at Rio. But now it does." He points out that ocean water moves and mixes globally, spreading local warmth to far-away regions.

Theo Colborn
zoologist, World Wildlife Fund

Colborn has called attention to the vast number of **synthetic chemicals** known as hormone disruptors, which interfere with development and reproduction in wildlife and humans. "My message didn't reach Rio," she says. "It was just emerging at that time. Governments still have no adequate systems to remove these chemicals from global commerce. Everyone is exposed to them every day, no matter where they live."

Hal Mooney
environmental biologist, Stanford University

"I think that Rio was a crucial **turning point** in how we approach environmental problems," says Mooney, who looks at how ecosystems like forests and grasslands deliver tangible services to Earth's inhabitants. "The very act of forging the conventions on climate, wetlands, desertification, and biological diversity has brought a focus to these issues and to the evolution of global mechanisms to deal with them."

THESE SCIENTISTS CONTRIBUTED THEIR VIEWS IN A [redacted] BY NATIONAL [redacted] AND MODERATED [redacted] SPETH, [redacted] OF THE [redacted] OF [redacted] STUDIES.

7 Signs of progress

Green Thinking

A new sensitivity to humanity's impact on the environment has triggered corrective actions by individuals and governments alike since Rio. Efforts include the 1997 conference in Kyoto, Japan, with its agreement among most industrialized nations to reduce global emissions. The U.S. government has withdrawn its support, citing potential harm to the economy. Meanwhile, Internet and mobile phone communications facilitate **grassroots** environmental efforts by a growing international network of activists. The Johannesburg Summit marks the latest call for nations to heed environmental threats.

Alternative Transportation

Gasoline-electric **hybrid cars** are already reducing carbon dioxide emissions in Japan, Europe, and the U.S. Innovators at Colorado's Hypercar, Inc., are trying to eliminate all such vehicle emissions. One of their automobile designs is powered by ■ hydrogen fuel cell that creates emissions you can drink: pure water. And the Segway Human Transporter, ■ gyroscope-balanced electric vehicle, is ■ new spin on individual mobility.

Ban on the Dirty Dozen

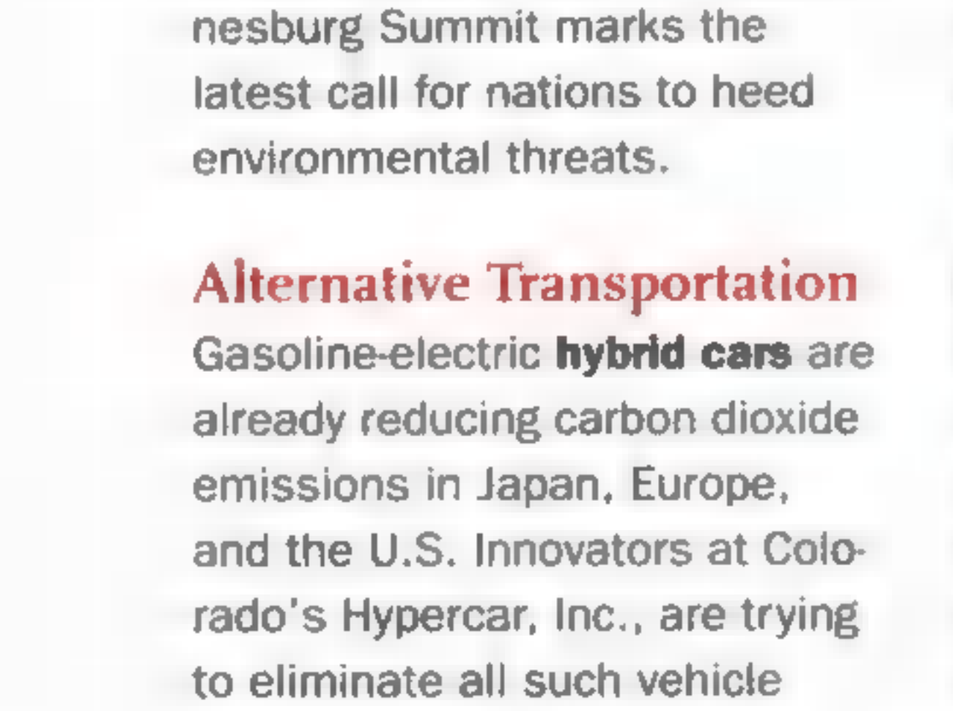
At a United Nations conference in Stockholm in 2001, a treaty was adopted to control 12 carbon-based, chlorinated chemicals. Aimed at cleaner air and water, the Convention on Persistent Organic Pollutants calls for restriction or elimination of chemicals such as chlordane, DDT, and PCBs. A 1987 **ban ■■ CFCs,** or chlorofluorocarbons, which destroy Earth's protective ozone layer, has stopped further release of these compounds.

Ecotourism

The U.S.-based International Ecotourism Society describes ecotourism as **"responsible travel** to natural areas that conserves the environment and sustains the well-being of local people." With an annual growth rate estimated as high as 30 percent, ecotourism and its projected profits have prompted governments across the developing world to protect natural areas as well as traditional cultures. But skeptics warn that ecotourism is often more a marketing ploy than a sign of a sensitive environmental approach.

Corporations Clean Up

Big business is realizing that conservation may help the bottom line. Xerox's Waste Free program **recycled** 80 percent of the nonhazardous solid waste generated by the corporation's factories in 2000. It also kept 158 million pounds of electronics waste out of landfills through remanufacturing. Saving several hundred million dollars a year, Xerox has been applauded by environmental groups for proving that sustainability is good for



DAIMLERCHRYSLER NECAR 5; REUTERS NEWMEDIA INC./CORBIS (LEFT); COSTA RICAN RAIN FOREST: FRANS LANTING, MINDEN PICTURES

Ozone-killing chlorofluorocarbons have been reduced to less than a seventh of their use prior to 1987. *UN Environment Programme*

business. This mindset had surfaced at the 1999 World Economic Summit in Davos, Switzerland, where attendees first declared climate change to be the most pressing global problem facing businesses.

Healthier Buildings

Environmentally sensitive buildings are **reducing energy use.** Examples include European buildings outfitted with solar roof tiles and a Gap Inc. office in San Bruno, California, whose roof is covered with insulating native grasses. The Chesapeake Bay Foundation headquarters in Annapolis, Maryland, might be the greenest of them all, with composting toilets, cisterns that collect rainwater, and solar panels to generate electricity. The building uses one-third the electricity and one-tenth the water of comparably sized buildings.

Acid Rain Reduction

The U.S. and Europe have proved how quickly the planet's face can be cleaned by **lowering emissions** of sulfur dioxide and nitrogen oxides. In the 1980s developed nations began curbing the release of sulfur dioxide, a product of coal-fired power plants, by switching to natural gas and cleaner coal to generate electricity. And thanks to catalytic converters and cleaner fuels, automobiles are emitting lower levels of nitrogen oxides. The acidity of rain in the United Kingdom, for example, has been reduced by half in 15 years.

7 Setbacks

Global Warming

This issue triggers alarms for many scientists, who predict higher sea levels and violent weather due to a greenhouse effect from the burning of fossil fuels. NOAA reported that the average temperature for the continental U.S. from November 2001 to January 2002—39.8°F—was the warmest for the three-month period since measurements began in 1895. Worldwide, this past January was the **warmest on record,** with an average temperature of 54.9°F.

An Appetite for Oil

A veritable river of oil—5,000 cubic feet—flows out of wells every second. Oil consumption grew 14 percent during the 1990s, and this burned fuel accounts for some 40 percent of the 24 billion tons of carbon dioxide added to the atmosphere annually. Ice cores reveal that this primary greenhouse gas is now at its highest level in 420,000 years. Two-thirds of the world's oil reserves lie in the Persian Gulf region, where political instability and the **threat of conflict** jeopardize oil flow.

Disappearing Wetlands

Freshwater and saltwater wetlands remove pollutants and provide habitat for fish, migrating birds, and other wildlife. From the Amazon Basin to Iraq, wetlands are being drained for agriculture, dams, and development. Scientists estimate that 50 percent have been **destroyed** in the past century. A forerunner of the Rio summit, the global Convention on Wetlands was signed 31 years ago in Ramsar, Iran. Although the treaty now includes 132 contracting nations committed to sustaining their wetlands, its actual impact on halting wetlands' disappearance has been disappointing.

Rise of Megadams

Large dams alter the flow of rivers and drown land with reservoirs, interfering with fish migration and flooding cultural sites. In 1950 there were 5,000 large dams worldwide. By the year 2000 the number had grown to 45,000. That's an average of two new large dams (higher than 50 feet) completed each day, half of them in China. Some 600 feet high and more than a mile wide, Three Gorges Dam on the Yangtze River may displace nearly two million people and flood an estimated 240,000 acres of cropland when completely operational in 2009. The Rio Grande, dammed at several points in the U.S. and Mexico, last year **ran dry** at its mouth.

The amount of water impounded behind dams has measurably affected the speed at which Earth spins. *NASA*

Coral Reefs

Home to a fourth of all marine species, coral is the ocean's canary in a coal mine. Oceans have lost 27 percent of their coral in the past 50 years—16 percent during the 1998 El Niño alone—according to the Coral Reef Alliance. Biologists are monitoring a **bleaching** trend, in which algae inside coral polyps are expelled because of increased solar radiation and warmer water, often killing the coral. Fishermen have accelerated the decline of healthy coral by using explosives and cyanide to kill and collect fish around delicate reefs.

CYPRESS [illegible] JIM RICHARDSON (LEFT); NORTH SEA OIL RIG: MARK [illegible], GETTY IMAGES

Overfishing

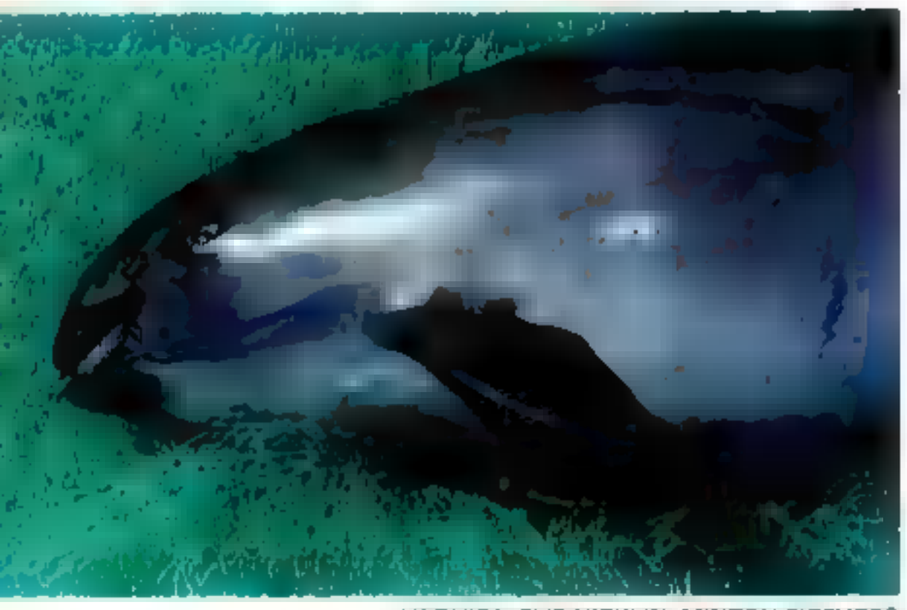
Technology has enabled humans to haul in more fish than the oceans can replace. [illegible] fish populations such as bluefin tuna, groupers, and cod are **plummeting.** As catches decline by about one percent annually, the Ocean Conservancy warns that we are "spending the principal" of our marine resources rather than living off the interest. Scientists are calling for large swaths of ocean to be designated as marine reserves closed to fishing, where stocks can recover. The problem has yet to impress the public, as farmed fish and lower prices from advances in fishing technology have combined to control the cost of many fish at the market, masking the reality of shorter supply.

Nuclear Waste

This year the world's some 440 commercial nuclear reactors will create more than 11,000 tons of radioactive spent fuel. The waste **poses a risk** in the form of accidental leakage and as a terrorist target. In the U.S., home to nearly [illegible] quarter of the world's reactors, 161 million people live within 75 miles of an aboveground waste storage site. Pending national debate and more studies, these 131 sites in 39 states may send their waste to be entombed beneath Nevada's Yucca Mountain starting in 2010.

7 Species on the brink

SUMATRAN RHINO: DAVID TIPLING, NATURE PICTURE LIBRARY



VAQUITA: FLIP NICKLIN, MINDEN PICTURES

Vaquita

Critically endangered, this smallest of porpoises measures barely five feet at maturity. Spanish for "little cow," referring to its large, dark eyes, the vaquita lives at the northern end of the Gulf of California, where it has the smallest home range of any marine cetacean. **Gill nets** set for sharks, rays, and other species and trawl nets set for shrimp prove deadly, often snaring the rare porpoise. First identified in 1958, only a few hundred vaquitas remain. None have been successfully kept or bred in captivity.

Sumatran Rhinoceros

Surviving in scattered pockets in Indonesia and Malaysia, Asia's only two-horned rhino has seen its numbers halved in the past decade alone. **Poachers** sell the horns for traditional medicine. Observers call it the "hairy" rhino because of the unique coat of shaggy hair that often covers younger animals. Today's population: only about 300 individuals.

Spix's Macaw

The lone wild survivor of this species, a male, was last seen in its native woodland of northeastern Brazil in October 2000. Growing up to two feet long and feathered in rich hues of blue and gray, Spix's macaws were long **trapped** and shipped abroad to collectors and traders of exotic birds. A breeder in the Philippines is said to have received as much as $80,000 a bird. Perhaps 60 live in captivity, virtually all in private hands. Logistic and legal obstacles have made it difficult to organize attempts to reintroduce this macaw to the wild. And even before it was discovered in the early 19th century, its habitat had been falling to settlement.

Kihansi Spray Toad

This tiny African amphibian holds the distinction of having one of the most restricted ranges of any vertebrate on the planet: a hop, skip, and a jump on either side of waterfalls in Tanzania's Kihansi River Gorge. Sustained by mist from the falls, the toads thrived for unknown eons before their discovery in 1996. In April 2000 the Lower Kihansi Hydropower Project began to divert water from the falls and dried up 95 percent of the toad's fragile **microhabitat.** A sprinkler system has been installed to re-create the spray, but captive breeding now being attempted in U.S. zoos may be the toad's only chance for survival.

Three-striped Box Turtle

Native to southern China and northern Vietnam, this turtle has become a symbol of the steep decline of Asian freshwater turtle populations. As China's **economy** booms, many of its citizens are indulging an ancient passion for turtle meat. Traditional Chinese medicine values the flesh of the three-striped box turtle for its purported cancer-curing properties.

American Burying Beetle

The largest member of the carrion beetle family in North

"Large numbers of species are crossing the thin zone from the critically endangered to the living dead and thence into oblivion." *E.O. Wilson*

America, these nocturnal scavengers play an important role in recycling decaying animals back into the ecosystem. Though only one-and-a-half inches long, the beetles bury carcasses as large as chipmunks and quail for later consumption by their young. Once plentiful in the U.S. east of the Rockies and in southeastern Canada, their natural range is now limited to parts of Arkansas, Oklahoma, Kansas, Nebraska, South Dakota, and the offshore shelter of Block Island, Rhode Island. Fragmented habitat may be responsible for their disappearance, along with increased **competition** for carrion from foxes, skunks, and raccoons.

Café Marron

A plant in the coffee family native to the island of Rodrigues in the Indian Ocean nation of Mauritius, the café marron was down to only one known survivor in the 1980s. Cuttings sent to England's Kew Gardens were successfully propagated, and in 2001 the species was repatriated to the island. Unfortunately, the surviving plant and the cuttings are male, rendering the species unable to reproduce. Like a patient on life **support,** the café marron's disappearance is merely delayed. Scientists note that island extinctions may forewarn of greater losses on the continents.

SPIX'S MACAW: NICK GORDON, NATURE PICTURE LIBRARY (LEFT); AMERICAN BURYING BEETLE: MARK W. MOFFETT, MINDEN PICTURES

7 Sanctuaries

Kruger National Park

A vast stretch of bush and savanna, South Africa's Kruger National Park contains one of the world's largest concentrations of mammals. With its origins going back to 1898 when two game reserves were established, the 7,523-square-mile park shelters 147 mammal species, including cheetahs, white rhinos, and wildebeests, as well as more than 500 bird species. Kruger may soon become part of an **innovative,** tri-country reserve called the Great Limpopo Transfrontier Park with border-sharing portions in Mozambique and Zimbabwe.

Tubbataha Reef National Marine Park

This 1988 triumph of conservation over unsustainable fishing practices lies in remote Pacific waters. Tubbataha spans two atolls in the Philippines and covers 128 square miles of rich marine biodiversity. Some 450 fish species thrive there. With all forms of fishing now illegal, the park offers many marine stocks ■ place where they can **bounce back.**

Prespa Park

Prespa may do for the Balkans what **transboundary** parks are attempting to do in Africa—foster peace. In 2000, the governments of Albania, Greece, and Macedonia signed an agreement to create Prespa and protect its wetlands, vital breeding ground for more than 160 bird species, with another hundred bird species observed. Sheltering two of Europe's oldest lakes, Prespa and Mikri Prespa, the park will protect breeding habitat for great white pelicans and the world's largest breeding colony of rare Dalmatian pelicans.

Bahuaja-Sonene National Park

Deep in Amazonian Peru, some 2.7 million acres of forest have been put off-limits to logging. Bahuaja-Sonene is part of the vast Tambopata-Candamo reserve set aside in 1990 to protect the **watersheds** of three rivers. Two years ago much of the reserve was elevated to national park status, freeing it from hunting and trapping. Within this green world exist more than 200 mammal species, 900 bird species, and 1,200 butterfly species.

Nahanni National Park Reserve

Split by the roaring South Nahanni River, the roadless Nahanni Park in the Northwest Territories covers 1,840 square miles of Canada's most rugged and pristine landscape. Its marvels include the Nahanni River Gorge, touted ■■ Canada's Grand Canyon, and thundering 302-foot Virginia Falls, nearly twice the height of Niagara Falls. The remote park sees only about 900 visitors ■ year. Set up in 1976, Nahanni was chosen two years later by UNESCO ■■ one of the first **World Heritage sites.**

Royal Chitwan National Park

In the foothills of Nepal's Himalaya, crocodiles lurk in the tall grasses of Royal Chitwan. Where the country's south-central lowlands border India, Royal Chitwan protects more than 50 species of mammals, many of which, including Indian rhinoceroses and Bengal tigers, have **increased** in number since the park's founding in 1973. Annual visitors have risen from fewer than 1,000 to more than 100,000 today.

The Goualougo Triangle

This African region has become ■ stage for timber companies to demonstrate that they can preserve the **ecological capital** they usually destroy. Last year Congolaise Industrielle des Bois turned over ■ hundred square miles of untouched rain forest adjacent to the Nouabalé-Ndoki National Park, Republic of the Congo. The reserve harbors some of the world's highest densities of gorillas and chimpanzees.

■■■■ NATIONAL PARK, CANADA: PAUL NICKLEN

Nearly 10 percent of the Earth's land surface, an area larger than Antarctica, is protected. *World Conservation Union*

So where does this leave us? Closing thoughts from the seven scientists.

E. O. Wilson

"The clearing of tropical forests appears to be the same ▬ it was ten years ago. If present rates continue, we will severely undercut the base of natural resources on which humanity depends. Put another way, we are ruining the natural economy on which the market economy depends. And, as an unintended consequence, we may extinguish half the species of plants and animals by the end of the 21st century. We are more aware of the mechanics of habitat destruction, so if these considerations don't make us **change our ways,** I'm afraid nothing will."

Jane Lubchenco

"If you ask people, 'How do you depend on nature?' most will focus on things: food, fiber, medicines, and more recently genes. Most people are unaware of the concept of '**ecosystem services.**' These are benefits provided by intact ecosystems: cleansing of air and water, partial climate regulation, making of fertile soils, provision of habitat, and control of pests and pathogens. Only when we begin to lose these services do we realize they're valuable."

Sherry Rowland

"What may be required to concentrate people's minds on the planet's health is a climate surprise. A theoretical example is a **permanent El Niño.** The last time El Niño happened we got 32 inches of rain in a season in southern California. Another might be ■ centuries-long shutdown of the Gulf Stream, which happened about 12,000 years ago. My question: Is climate change a gradual dial or a quick switch?"

Wes Jackson

"The link between the land and the oceans hasn't received enough attention. What I'd like to see addressed at Johannesburg is the connection between

"Our society will be defined not only by what we create, but by what we refuse to destroy." *John [illegible] Sawhill, The Nature Conservancy*

agriculture and the need to feed **increasing numbers** of people, and what that means for the oceans. I used to say if we don't do something about agriculture, then wilderness is doomed. Now we can add to that, if we don't do something about agriculture, the oceans are doomed."

Richard Barber

"The most important thing that average people can do is tell their leaders they want answers. Imagine how people felt a hundred years ago when hurricanes came in off the sea and devastated them. Today it's clear that our government has demystified hurricanes, has shown how they happen, can predict them, and therefore we can respond in time to **reduce suffering.** What [illegible] need now is equivalent demystification of climate change."

Theo Colborn

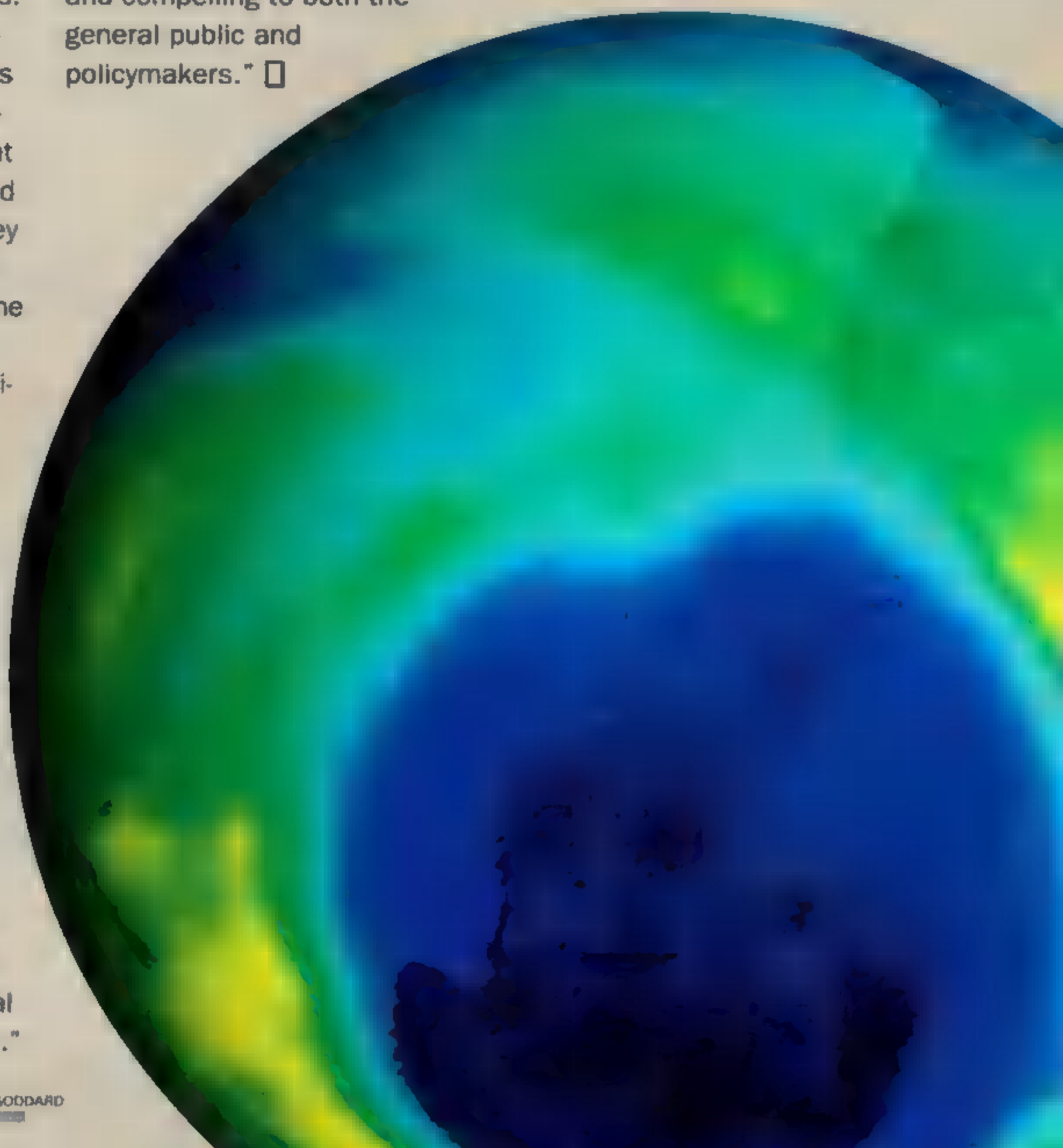
"There is now **enough evidence** that some of the widely used petroleum-derived chemicals can enter the womb and undermine the development of the brain and the immune and reproductive systems. This is of concern because the world needs healthy, brilliant, and compassionate statesmen and stateswomen with the commitment to restoring environmental stability and peace to the world."

Hal Mooney

"The record shows time and again that one person or a small group can **awaken** the public to the importance of an issue and bring about a startling change in the direction of a society. Scientists are working together as never before to protect the biological richness of the Earth. The challenge [illegible] have now is to make our findings clear and compelling to both the general public and policymakers." □

MORE INFORMATION

What can one person do [illegible] help the health of the planet? Post your thoughts [illegible] our online Forum at **nationalgeographic.com/ngm/0209.** Also find links and resources selected by our Research Division, including a link [illegible] the Goldman Environmental Prize, awarded to individuals who have made a difference.



ANTARCTIC OZONE HOLE, SEPTEMBER [illegible], 2001: NASA GODDARD SPACE FLIGHT CENTER, SCIENTIFIC VISUALIZATION [illegible]

ZipUSA

NEW YORK CITY

Twin beacons rise just beyond TriBeCa, a neighborhood near the World Trade Center site, to commemorate Manhattan's darkest, and bravest, hour.

10013

After the Fall

PHOTOGRAPHS BY IRA BLOCK

Four blocks from the World Trade Center (zip code 10048) is code 10013 [illegible]. The fall of 10048 is told by a firefighter whose house lost 14 men on September 11. Two 10013 residents [illegible] out the [illegible].

NEW YORK CITY

Under I After the towers collapse, I arrive on the scene. There are no streets, only caverns of destruction, filled with sections of I beams, aluminum facade, dust, paper, and mud. Buildings surrounding what will come to be known as ground zero are gutted, burning fiercely, have hundreds of broken windows, or have been ripped wide open by flying girders. The command system is shattered; a chief is yelling orders from atop a rig. Every man seems to be from a different unit, and most lack basic equipment. We stretch hose lines to control fires in the acres of rubble, and pass stretchers, breathing masks, and

Lisa Grimes (left) barely remembers grabbing a camera to capture the towers' collapse from her terrace. "I don't trust my memory of that day," she says. More than 5,000 photos bear witness at the September 11 Photo Project (above).

Ladder Company 8 welcomes kids to a firehouse Christmas party (above). Nikie, a therapy dog from the K-9 Disaster Relief organization, offers firemen his own greetings.

forcible-entry tools over the girders to try to rescue trapped firemen.

Later I find my company, Ladder 15, at a staging area, where they've set up chairs outside the shattered windows of an office building's backside, like some war zone Parisian café.

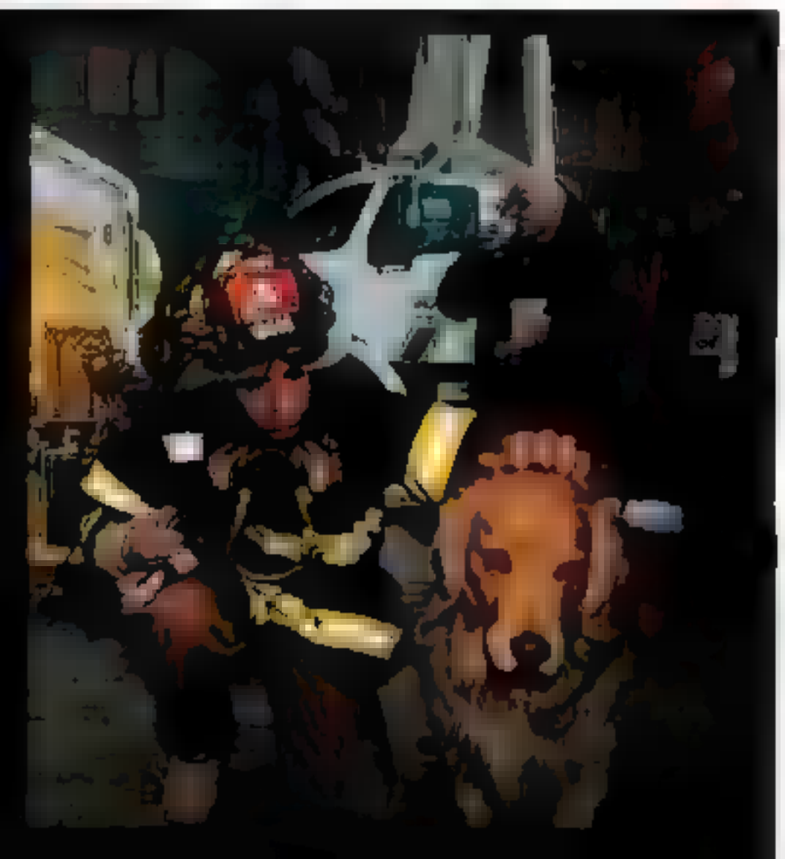
After a few hours of awaiting orders, we split up to look for work. I find a large contingent of firefighters and police on the south side of Tower 2's remains, snaking a hose line into the rubble's smoky darkness. I search for victims under the wreckage. No sign of anyone.

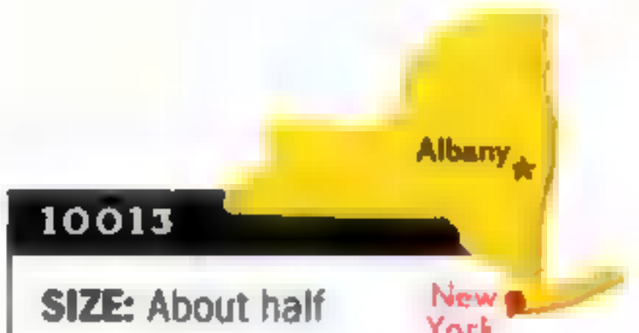
From time to time the smoke lifts a little, showing six stories of uncollapsed steel girders and concrete flooring looming overhead. I keep searching, making mental notes of what girder I'll duck under if the rest of the building gives way.

Men shout for relief at the end of the hose line. I follow the line into intense heat and choking smoke. About a half hour later I reach the end and offer to take the nozzle, but the nozzleman refuses. "I'm not going anywhere until Duncan comes back!" he yells. By tradition, a company keeps the nozzle until the fire is out and firefighters from the house are safe. I help feed in hose, then start back to get some tools. Suddenly I feel sick and dehydrated. Hundreds of hands steady me as I clamber over rubble and down ladders that the brothers have laid across the steepest sections.

In the triage center in the firehouse across the street, the nurses seem like angels with IVs. Before I fall asleep, I think back to the afternoon, when firefighters and construction workers fired up earthmoving equipment and started clearing the street. Only hours after the collapse of the towers, the recovery had begun.

—NOEL MAITLAND





10013

SIZE: About half a square mile

NEIGHBORHOODS IN 10013: TriBeCa, the "*TRI*angle *BE*low *CA*nal" Street; Chinatown; Little Italy; SoHo

POPULATION IN 2000: 25,000

DISTANCE TO GROUND ZERO: Four blocks

NUMBER OF FIREHOUSES: T[illegible]

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SUBARU

The Beauty of All-Wheel Drive.

Canto II You know my neighborhood. Last September, the sidewalk in front of my home became the backdrop for news reporters showing the world the devastation. My neighborhood, TriBeCa, just north of ground zero, also became a triage center when merchants threw open their doors to the injured and scared. It became a staging area for rescue workers searching for survivors in the smoldering rubble at the end of my street. And my corner was one where thousands streamed to pay final respects to those lost in a national tragedy that played itself out in an American neighborhood.

We had elementary schools and a canine day care center. We were also home to Miramax Films and some of the world's trendiest restaurants. We were an eclectic mix of artists, Wall Street brokers, and middle-class families. We are different now. Weary from the effort to recover and plagued by uncertainty, we are a neighborhood adrift.

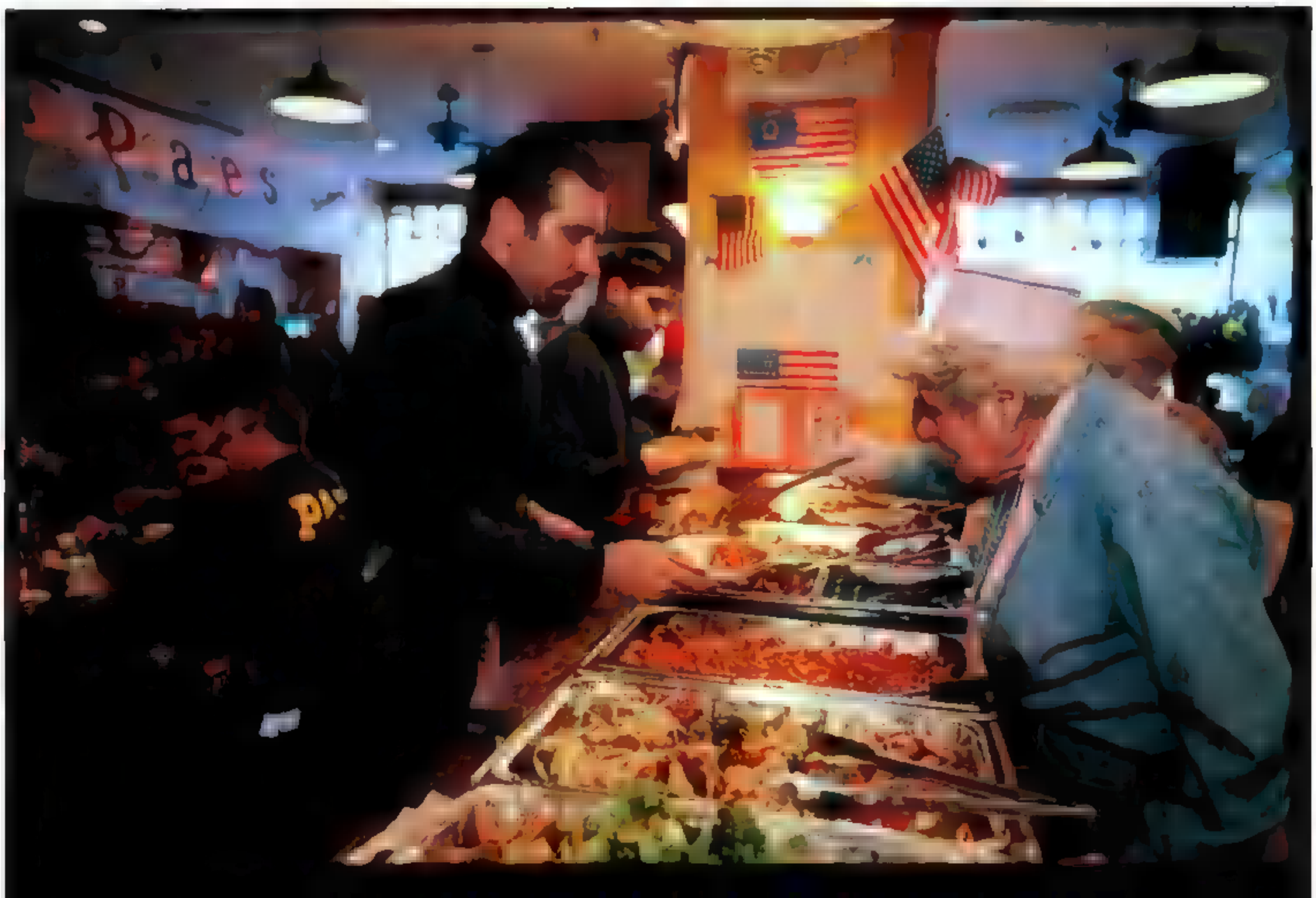
Paul, a neighbor, was the son of "homesteaders," middle-class families attracted here by city subsidies after the towers were built in the mid-seventies. Like so many Americans, he decided to raise his own family where he grew up. A month after the attacks, he packed up and left. For how long? I asked. "Forever," he replied.

A friend from uptown offered to walk me home one night. As we walked down my street, he grabbed my arm in alarm. "I know that smell," he said, of the ever present smoke in the night air, reminder of the fires still burning deep inside that diminishing pile. "I grew up next to a cemetery," he said. It was the smell of the crematorium.

I watched one morning as a father walked his son to school down my street. Once proud skyscrapers stood vacant, their facades burned and stripped, their offices charred honeycombs. The son took his father's hand and asked, "Where is the future?" His father replied, "The future is everywhere around you, at all times."

—DIANA [redacted]

Nino's Restaurant on Canal Street offered round-the-clock respite [redacted] ground zero workers. Volunteers dished out stress relief (above) and free food (below).



- [x] When you wake up
- [x] When you're taking a shower
- [x] When you're making your bed
- [x] When you have your coffee
- [x] When you're putting on your socks
- [x] When you're pouring your cereal
- [x] When you're reading the paper
- [x] When you're walking the dog
- [x] When you get in your car
- [x] When you're driving
- [x] When you get out of your car
- [x] When you're in the elevator
- [x] When you walk in your office
- [x] When you're checking your email
- [x] When the phone rings
- [x] When the phone doesn't ring
- [x] When you meet with your boss
- [x] When you meet with your clients
- [x] When you meet anyone at all
- [x] When you walk to the deli
- [x] When you order your sandwich
- [x] When you finish your pickle
- [x] When you leave the office
- [x] When you pick up your cleaning
- [x] When you stop to get gas
- [x] When you walk into the store
- [x] When you're squeezing the melons
- [x] When you're checking out
- [x] When you pull into your driveway
- [x] When you unload the car
- [x] When you check you
- [x] When you turn on t
- [x] When you're watchi
- [x] When you're peelin
- [x] When you're openin
- [x] When you finish eat
- [x] When you're having
- [x] When you're walkin
- [x] When you put on yo
- [x] When you're washin
- [x] When you're brushi
- [x] When you're gettin
- [x] When you're going
- [x] When you're countin

Brunch bustles again for a sidewalk café (left), and Jennifer Ford's prenatal yoga classes (below) are once again in full swing.

Canto III Weeks later, when the sirens had vanished from the night and we were no longer asked for passports, gas bills, and driver's licenses to prove that we lived in what we came to call the frozen zone, everything looked the same and everything felt different.

My wife, Fukiko, and I were lucky. We had been across the street when Tower 2 came down with the roaring sound of a steel-and-glass avalanche. We were engulfed by that cloud of dust that rose 25 stories above the street, a cloud so opaque that it looked like a solid. The cloud was made of pulverized floors, exploded glass, smashed desks, computers, food, file cabinets, and human beings. She and I were separated in the dust, found our way home separately, and celebrated the simple fact of being alive.

We were lucky in another way: In our loft 14 blocks north of ground zero, we had electricity. Television, telephones, the Internet all worked. So did we. For nine straight days, we wrote newspaper stories about the calamity. On the tenth day I wrote nothing and for the first time sat on a couch, thinking about the ruined world, and wept.

But life also provided its own consolations. In the streets we met some of our neighbors for the first time. We stood on street corners together, manual laborers and dot-com workers, mothers and children, all staring downtown at the smoldering stumps of the towers. We asked about children, and dogs, and survivors. The emotions of awe, horror, rage were gone quickly, replaced by a shared sense of vulnerability.

That is what remains: vulnerability. And from vulnerability there has emerged a tough fatalism. We all learned, that terrible morning, that we could die while reaching for a piece of toast at breakfast. Where I live, that knowledge has made us more human. Even on streets noisy again with traffic, strangers say good morning. Men kiss their wives more, and hug their children, and walk with them to the Hudson to embrace the sunset. But not one talks with utter confidence about tomorrow.

—PETE HAMILL

MORE INFORMATION

ON OUR WEBSITE Find out more about the city's recovery and share your reflections on September 11 ■ **nationalgeographic.com/ngm/0209.** Tell us why ■ should cover **YOUR FAVORITE ZIP CODE** ■ **nationalgeographic.com/ngm/zipcode/0209** or mail your suggestion to PO Box 98199, Washington, DC 20090-8199. E-mail: **zip@nationalgeographic.com**

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The Nature

Final Edit

MATTIAS KLUM

MEERKATS

Looking Good

It's mighty fine to be a meerkat with pals close by and the Kalahari sun on your fur. Sure, you're snack size to a lot of predators. And drought can make it tough to find enough beetles, grubs, and reptiles to fill your stomach. But despite the long survival odds faced by individual meerkats—adult mortality rates in one study area exceeded 50 percent annually—the species as a whole is doing well. Widely distributed across southern Africa, *Suricata suricatta* isn't considered endangered anywhere in its range.

They're certainly flourishing in our pages. When Editor in Chief Bill Allen chose this shot for Final Edit, one of the senior staff in the crowded layout room mumbled something about this issue "already showing a lot of meerkats." Bill looked around and replied: "You can *never* have too many meerkats."

MORE ON OUR WEBSITE

Cut it or keep it? Find out what tipped the balance for this photo and send it an electronic greeting card at **nationalgeographic.com/ngm/0209.**

EX model shown. DVD Entertainment System, wireless headphones and leather-trimmed interior available on EX with Leather only.

DVD Entertainment System

Leather-trimmed seats

Wireless headphones

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Horse whinnies

Tail

Saddle sores

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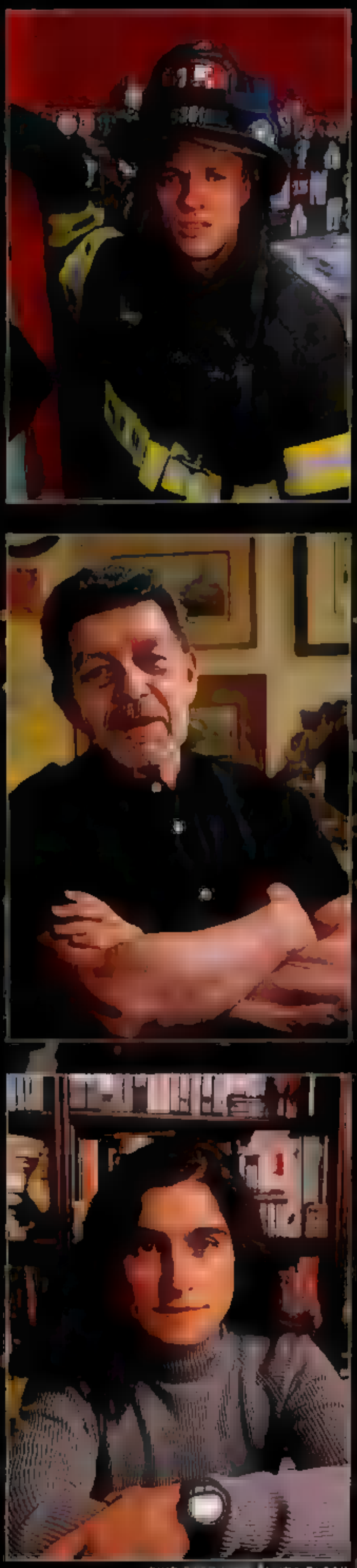
ON ASSI

ON THE ROAD, IN THE FIELD,



CHIP [illegible] IRA BLOCK

NEW YORK, [illegible] YORK

True Blue

A city [illegible] to heal

Photographer **Ira Block** (right), a native New Yorker [illegible] a few subway stops from ground zero, still [illegible]. "The attack on the World Trade Center is always on my mind," says Ira, who photographed zip code 10013 for this issue. "Whenever I hear a siren, I wonder if something has happened."

It's a feeling [illegible] by authors **Nani [illegible]** (who [illegible] a seven-year New York City [illegible] writer **Beth Hamill**; and **Diana Kane**, a 10013 resident who's [illegible] the city for 20 years. "My [illegible] husband has been dying since the attack," Diana says. "We've been adrift. We have this feeling it's not the place we want to be anymore. I'd move in a heartbeat, but I don't know where."

For [illegible] in blue on the 88th floor of the Empire State Building [illegible] the lights that often paint the top of the building in the colors of the American [illegible] the disorientation [illegible] compounded because the natural [illegible] things [illegible] reversed.

"I'm always traveling when I'm on assignment, but all I [illegible] is home," he says. "Usually when I finish a job, I leave. Here I'm not done with it, and I don't [illegible]."

[illegible] MBER

GNMENT

COVERING THE WORLD

SOUTH AFRICA

Standing Tall

So there was **Mattias Klum** (right), minding his own business, just sitting taking pictures. "Suddenly I felt a scratching, clawing thing on my back," he says, "and I realized I had a meerkat climbing me."

To us Mattias looks like a photographer. But to a meerkat he was a perfect platform on which to watch for predators. "Meerkats look for the highest possible location in the terrain—a bush or a log or anything they can find," Mattias says. "This guy realized it was his turn to be a sentinel for the group, and so he climbed up Mount Klum."

Meerkats are shy and elusive, but some have grown accustomed to visiting scientists. "This was one of the habituated ones," Mattias says. His stint as a perch lasted only a few minutes. "I'm not as steady as a rock, even though like all photographers I like to think I am," he says. "After a while, he gave up."

The Swedish wildlife photographer's most recent article in NATIONAL GEOGRAPHIC chronicled the life and times of king cobras. "It was interesting going from one of the most feared creatures on Earth to such a loved one," says Klum. "The only thing to fear from a meerkats assignment is the rabies shots."

Tim Clutton-Brock would like you to know that he doesn't study meerkats because they're cute. After all, female meerkats often kill other mothers' babies—"definitely not cute behavior," says Tim, professor of animal ecology at the University of Cambridge. No, the reason he has spent nine years in the Kalahari with meerkats is that they're easier to track than mole rats, which live underground, or marmosets, which live in trees. But why study any of them? Because they practice an odd child-care strategy called cooperative breeding, in which some individuals help others with child care rather than breed themselves. "Someone once said that science is the art of the soluble," he says, "and you seldom solve important questions by working on the most difficult species."

LARS MAGNUS EJDEHOLM

WORLDWIDE

"In Turkey," says author **Erla Zwingle,** "they dance all the time." Exploring the Black Sea coast, Erla and her guide, **Aydın Kudu,** stopped at ■ sidewalk café. A crowd gathered, and someone pointed to an older man, saying "He's the best violin player in town." The man opened his jacket, pulled out a *kemençe*, a small three-stringed violin, and began to play. "Watch," Aydın told Erla, "in a minute and a half someone's going to start dancing." Sure enough, Erla recalls, "you could see everybody start to feel the music, and soon they couldn't stand it anymore, and four men started dancing in the street."

Aydın, a professional tour guide who has worked with several NATIONAL GEOGRAPHIC authors and photographers, calls himself "a translator, a fixer: I arrange hotels, transportation, logistics." Erla calls him and his kind cultural interpreters: "Aydın picks up on little fleeting things that even if I saw them or heard them, I wouldn't know that they mattered —maybe a little bit of banter between two people on the street. He's one of the best."

MARK THIESSEN, NGS

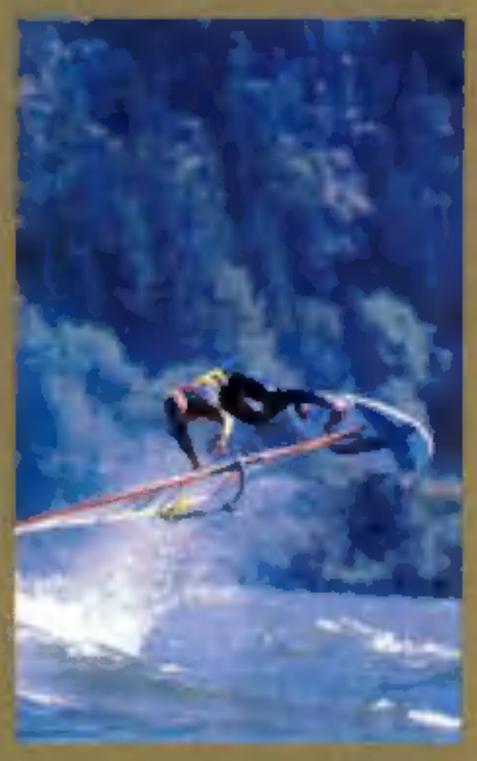
A Curious Character

Joel Achenbach (left) says he's "amazed and sometimes bewildered by science." He satisfies his curiosity by "lobbing questions—no matter how ignorant they may sound—at leading scientists." He'll share what he learns in the magazine's new monthly science page, Who Knew? (replacing Ask Us starting in this issue). Joel, a staff writer for the *Washington Post*, is the author of five books, including *Captured by Aliens*. "It's not a memoir," he insists.

HOT OFF OUR WEBSITE

Find ■■■ stories from our authors and photographers, including their best, *worst, and quirkiest experiences*, at **nationalgeographic.com/ngm/0209.**

Where sport meets adventure



Mt. Hood: Elevation 11,237 ft

Big Brother Falls: over 1,500 cu ft per sec

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Flashback

BETTMANN/CORBIS

ZIP NYC

Skyline Salute

Even the skyscrapers of Lower Manhattan seemed to stand taller when the *United States* steamed past before her maiden voyage to France and England in 1952. She was the largest passenger ship ever built in the U.S., and her three-day transatlantic passage broke the previous speed record held by Britain's *Queen Mary.* "After the loud and fantastic claims made in advance for the liner *United States,*" complained *Punch,* the British magazine, "it comes as something of a disappointment to find them all true."

The ship sailed for 17 years. She's now docked in a Philadelphia port, awaiting renovation.

This photograph has never before been published in NATIONAL GEOGRAPHIC.

MORE ON OUR WEBSITE

You can send this month's Flashback as an electronic greeting card and access the Flashback photo archives at **nationalgeographic.com/ngm/flashback/0209.**

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